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PHAEOSPHAERIA SPARTINICOLA, A NEW SPECIES ON *SPARTINA*

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Abstract. - *Phaeosphaeria spartinicola* sp. nov. is described from the East coast of North America on *Spartina*. It is distinct from *Ph. typharum* in the morphology of the ascomata, which have a well developed beak and a peridium composed of flattened cells, in size and shape of the ascospores, in growth rate and colony characteristics in culture, and in the different host. In addition, the electromorphs of nine out of ten enzymes were different compared to those of *Ph. typharum*. Isozyme data suggest that the *Stagonospora* sp. with seven-septate conidia on *Spartina* is not the suspected anamorph of *Ph. spartinicola*.

INTRODUCTION

Species of the ascomycetous genus *Phaeosphaeria* Miyake are commonly found on grasses and other grasslike monocots. Some species are highly specialized to certain host plants, while others have a wider host range. A few species cause serious diseases on cereals including *Ph. avenaria* (G.F. Weber) O. Erikss. on oat and *Ph. nodorum* (E. Müller) Hedjaroude on wheat (Weber 1922; Brönnimann 1968). The known anamorphs of *Phaeosphaeria* belong in *Stagonospora* or *Scolecosporiella* (Leuchtmann 1984).

Recently, several taxonomic studies on *Phaeosphaeria* that include mostly European species have been completed (Holm 1957; Eriksson 1967; Hedjaroude 1968; Leuchtmann 1984, 1987). For species in Canada a taxonomic revision was conducted by Shoemaker and Babcock (1989). However, none of these studies pretends to include all the potential *Phaeosphaeria* species, thus leaving many hosts unexplored.

From *Spartina*, a common grass in marine coastal zones, several species of *Phaeosphaeria* have been reported (Kohlmeyer and Kohlmeyer 1979; Shoemaker and Babcock 1989). *Ph. spartinae* (Ellis & Everhart) Shoemaker & Babcock, and *Ph. halima* (T.W. Johnson) Shoemaker & Babcock appeared to be strictly specialized on that host. However, the predominant ascomycete of dead leaves of *Spartina alterniflora* Loisel. was so far always identified as *Ph. typharum* (Desm.) L. Holm (Gessner 1977; Kohlmeyer and Kohlmeyer 1979; Newell and Fallon 1983). Newell et al. (1989) have shown that what they referred to as *Ph. typharum* is an important saprotrophic producer in the standing-dead leaves of *S. alterniflora* in Georgia (USA) saltmarshes. This fungal species was originally described from *Typha* and was thought to be host specific (Leuchtmann 1984).

The present study was undertaken to evaluate the taxonomic position of the fungus on *Spartina* in comparison with *Ph. typharum* from *Typha* based on their morphology, characteristics in culture and isozyme variation. In addition, isozyme patterns of a commonly found *Stagonospora* on *Spartina* and of *Ph. halima* were compared to confirm a suspected anamorph-teleomorph relationship between the *Stagonospora* species and *Phaeosphaeria.*

MATERIALS AND METHODS

Morphological studies were conducted on freshly collected samples and on older herbarium specimens. Measurements of spores and asci were taken from material mounted in water. All isolates were obtained from single ascospores or conidia collected on Sapelo Island, Georgia, USA, or in Switzerland (Table 1). Swiss strains were those isolated and studied by Leuchtmann (1984). Growth rates and colony characteristics were recorded from cultures grown on malt extract-agar (MA; 1.5 % malt extract, 2 % agar) and incubated at 20° C in the dark. Induction of anamorph and teleomorph formation was attempted in cultures on MA exposed to near UV-light (370 nm) at 15° C for 3 months. All specimens examined are deposited in ZT. Representative isolates are maintained at ETH-Zürich and are deposited at CBS, Baarn, The Netherlands.

Isozyme analysis was conducted as previously described (Leuchtmann and Clay 1989). Cultures were grown on autoclaved liquid V-8 medium (100 ml centrifuged V-8 juice, 10 g D-glucose, 2 g L-asparagin, monohydrate, 1 g KH_2PO_4, 0.5 g $MgSO_4 \cdot 7 H_2O$, 0.25 g KCl, 10 mg $FeCl_3$, and 50 mg chloramphenicol in 1 liter H_2O; pH at 6.0) for 10 days. Enzymes were extracted from lyophilized samples, absorbed onto paper wicks and subjected to electrophoresis on horizontal starch gels. Ten enzymes were selected and staining performed after Soltis et al. (1983): acid phosphatase (E.C. 3.1.3.2), aconitase (E.C. 4.2.1.3), aldolase (E.C. 4.1.2.13), glucose-6-phosphate dehydrogenase (E.C. 1.1.1.49), leucine aminopeptidase (E.C. 3.4.11.1), malate dehydrogenase (E.C. 1.1.1.37), phosphoglucose isomerase (E.C. 5.3.1.9), phosphoglucomutase (E.C. 5.4.2.2), 6-phosphogluconate dehydrogenase (E.C. 1.1.1.44), and triosephosphate isomerase (E.C. 5.3.1.1). The isozyme data were interpreted phenotypically, and each banding pattern (per enzyme and isolate) was considered a different electromorph. Electromorphs were designated alphabetically in order of increasing anodal migration. For a given isolate the combination of electromorphs of the ten enzymes is termed isozyme phenotype (Table 1). In all isolates and for all enzymes a single banded pattern was resolved with the exception of malate dehydrogenase where always two major bands were evident.

SPECIES DESCRIPTION

Phaeosphaeria spartinicola Leuchtmann, sp. nov. - Fig. 1

Ascomata dispersa vel gregaria, immersa in mesophyllo, rostrata, globosa, glabra, 90-140 µm diam.; paries 10-14 µm crasso, 3-4 stratis cellularum brunnearum, tenuitunicatarum, complanatarum, 6-10 x 2-4 µm, composito; rostrum centrale, conicum, inclusum, 30-40 µm lat., e 2-3 stratis cellularum composito; stratum exterior e cellulis brunneis, rectangularibus, interior antem hyalinis, isodiametricis; ostiolum periphysatum; pseudoparaphyses non numerosae, hyalinae, septatae sparsim, 2-2.5 µm latae. Asci bitunicati, cylindracei vel ovoidei, breviter stipitati, 65-85 x 24-26 µm, 8-spori. Ascosporae imbricate distichae vel irregulariter conglomeratae, late fusiformes, 23-35 x 9-13.5 µm, ratio longitudinis/latitudinis 2.6-2.8, rectae vel leniter curvatae, brunneae vel flavo-fuscae, crassitunicatae, subtiliter echinulatae, 3-septatae, ad septa constrictae, loculo secundo leniter inflato, guttulatae, strato mucoso ad 2 µm circumdatae, evanescenti in sporis maturis.
Hab. in foliis siccis *Spartinae.*
Holotypus: ad *Spartinam alternifloram*, Georgia (USA), Insula Sapelo, VII. 1990, leg. S. Newell (ZT).

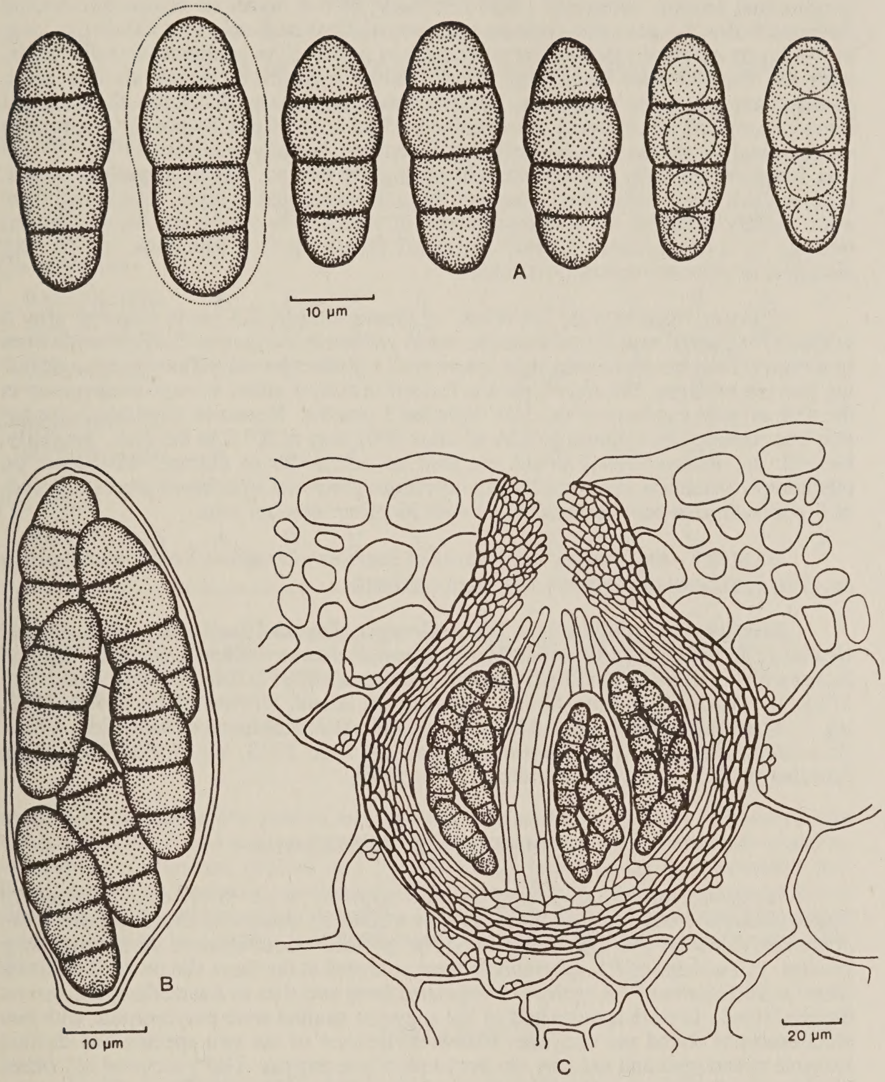

Figure 1. *Phaeosphaeria spartinicola* (Holotype, ZT): A. ascospores, second from left with sheath, seventh is immature; B. ascus with ascospores; C. section through leaf tissue and ascoma.

Ascomata scattered to densely concentrated on leaves, immersed within mesophyll with beak penetrating epidermis, globose, glabrous, 90-140 µm in diameter; wall in longitudinal section uniformly 10-14 µm thick, of 3-4 layers of brown thin-walled flattened 6-10 x 2-4 µm cells; beak central, conical, flush with substrate, 30-40 µm long, of 2-3 layers of brown rectangular cells outside, and hyaline isodiametric cells inside, with the ostiolar pore lined with short hyaline cylindrical periphysis-like cells; pseudoparaphyses not numerous, hyaline, sparsely septate, 2-2.5 µm thick. Asci bitunicate, cylindrical to ovoid, short-stalked, 65-85 x 24-26 µm, 8-spored. Ascospores overlappingly biseriate or irregularly conglomerated, broadly fusiform, 23-35 x 9-13.5 µm, length/width ratio 2.6-2.8, straight or slightly curved, brown to yellow brown, thick-walled, finely echinulate, 3-septate, slightly constricted at septa, second cell from apex slightly enlarged, with a large guttule in each cell in young spores, surrounded entirely by a conspicuous sharply delimited sheath up to 2 µm thick, which may disappear in older or overmature material.

CHARACTERISTICS IN CULTURE. - Colonies on MA 2.5 cm in diameter after 4 weeks/20° C; aerial mycelium abundant, tan to yellowish, cottony or fluffy; margin even to somewhat arachnoid; reverse light brown with a distinct brown-yellow pigment diffusing into the medium. No anamorph was formed in culture either at room temperature in the dark or after exposure to near UV-light for 3 months. However, teleomorph formation was observed in a culture on MA of strain 9001 only at 20° C in the dark. Similarly, Newell and Fallon (1991) could not find an anamorph in culture, but report on teleomorph formation after transferring mycelium grown on autoclaved pieces of leaves of *S. alterniflora* to cornmeal agar made with 20 g/liter seawater salts.

HABITAT. - On standing-dead leaves of *Spartina alterniflora* Loisel. and *Spartina* sp. at the East coast of the North American continent.

MATERIAL EXAMINED. - USA: Georgia, Sapelo Island, July 1990, leg. S. Newell (ZT, Holotype).- Georgia, Sapelo Island, 9. January 1989, 6. March 1989, and January 1990, leg. S. Newell (ZT, 3 coll., culture no. 9001 [CBS 175.91], 9005 [CBS 176.91]). - CANADA: Nova Scotia, Cape Breton Island, St. Ann's Bay, 1. July 1973, leg. J. Kohlmeyer, on *S. alterniflora* (ZT, ex Herb. J. Kohlmeyer No. 3385). - New Brunswick, Shepody Bay, Hopewell Cape, 28. June 1973, leg. J. Kohlmeyer, on *Spartina* sp. (ZT, ex Herb. J. Kohlmeyer No. 3380).

ISOZYME VARIATION

Isozymes of ten different enzyme systems were studied in species of *Phaeosphaeria* from *Spartina* and *Typha* as well as in isolates of *Stagonospora* from *Spartina* (Table 1). *Ph. spartinicola* and *Ph. typharum* both showed variation among isolates. All isolates of *Ph. spartinicola* were collected at the same site on Sapelo Island, whereas the isolates of *Ph. typharum* originated from two sites in Switzerland and one on Sapelo Island. In each species half of the enzymes studied were polymorphic with two electromorphs found per enzyme. However, isolates of the two species had distinct isozyme phenotypes and only the electromorph of one enzyme (G6P) occurred in isolates of both species. Consequently, the genetic distance between the two fungi appeared to be considerable based on the isozyme variation of the ten enzymes. Considering the variation within isolates of *Ph. typharum*, American and Swiss strains still shared electromorphs of 5 or 6 enzymes depending on the strain.

In one collection from Sapelo Island isolates of a *Stagonospora* with seven-septate conidia, and *Ph. halima* (referred to as *Leptosphaeria* cf. *peruviana* by Fallon and Newell 1989) were obtained from the same piece of leaf from which *Ph. spartinicola* was iso-

Table 1. Isozyme phenotypes of *Phaeosphaeria* and *Stagonospora* isolates from *Spartina* and *Typha.*

	[a]ACP	ACO	ALD	G6P	LAP	MDH	PGI	PGM	6PG	TPI
Ph. spartinicola										
[b]9001 (5), USA	D,E	D	B	D,E	B	D	A,B	C	B	E
9005 (2), USA	D,E	D	B	E	B	D	A,B	A,C	B	D,E
Ph. typharum										
9004 (2), USA	F	B	A	E	C	A	D	B	D	B
9377 (1), SUI	F	C	A	E	A	A	D	E	D	C
9382 (1), SUI	C	C	A	E	A	A	D	E	D	C
Stagonospora sp.										
9002 (5), USA	B	A	C	A,B	-	B	C	D	A	-
Ph. halima										
9003 (3), USA	A	E	C	C	-	C	E	D	C	A

[a] enzymes studied: ACP = acid phosphatase, ACO = aconitase, ALD = aldolase, G6P = glucose-6-phosphate dehydrogenase, LAP = leucine aminopeptidase, MDH = malate dehydrogenase, PGI = phosphoglucose isomerase, PGM = phosphoglucomutase, 6PG = 6-phosphogluconate dehydrogenase, TPI = triosephosphate isomerase.

[b] culture no., number of isolates (in parenthesis), and provenance from Sapelo Island (USA) or Switzerland (SUI).

lated. This *Stagonospora* species was listed as *Stagonospora* sp. II by Kohlmeyer and Kohlmeyer (1979) and was suspected to be the anamorph of *Ph. spartinicola* based on serological similarities (Fallon and Newell 1989). Isozyme analysis revealed that *Stagonospora* sp. had no electromorph in common with *Ph. spartinicola*, but had two electromorphs found also in isolates of *Ph. halima* (Table 1). These findings suggest that *Stagonospora* sp. on *Spartina* is probably not the anamorph of the often co-occurring *Ph. spartinicola.*

DISCUSSION

Distinct morphological characters and characteristics in culture, as well as variation in isozyme patterns justify the recognition of the fungus on *Spartina* as a species distinct from *Ph. typharum.* The ascomata of *Ph. spartinicola* have a well developed beak with periphyses, and a peridium wall composed in longitudinal section of small flattened cells. In *Ph. typharum* the ascomata are globular with an inconspicuous ostiolar pore and no apparent beak, and the cells of the wall are nearly isodiametric and often thickened in the outer layers (Leuchtmann 1984). In addition, the ascospores of *Ph. spartinicola* tend to be somewhat longer (up to 35 µm) with a larger length/width ratio (2.6 - 2.8) compared to the ascospores of *Ph. typharum*, where they reach only 32 µm in length with a length/width ratio of usually smaller than 2.6.

Colonies of *Ph. spartinicola* on MA-medium were slow growing (2.5 cm in diam. after 4 weeks), tan to yellowish, and formed a very distinctive pigment released into the medium. In comparison, colonies of *P. typharum* were faster growing (up to 5 cm in diam.), grey to black, and no obvious pigments were formed (Leuchtmann 1984). Comparisons made in this study with *Ph. typharum* strains from The United States were in line with these findings.

Isozyme data obtained from *Phaeosphaeria* isolates from *Spartina* and *Typha* showed that the two species can be distinguished on the basis of their isozyme patterns. In nine out of ten enzymes studied the isolates from the two hosts differed in their electromorphs. However, the small sample size from only few sites does not allow a conclusive estimate of the actual genetic distance between the two species. On the other hand, genetic distances of similar magnitude were also found in congeneric species of *Atkinsonella* (Leuchtmann and Clay 1989).

The anamorph of *Ph. typharum*, *Scolecosporiella typhae* (Oudem.) Petrak, can be found on the host plant as well as in culture where it is readily formed often together with the teleomorph (Webster 1955; Leuchtmann 1984). We tried to induce the formation of an anamorph with several strains of *Ph. spartinicola* under various conditions in culture, but no conidia were formed. A species of *Stagonospora* often found on *Spartina* leaves in close vicinity of *Ph. spartinicola* was previously suspected to be the anamorph, based on serological similarities (Fallon and Newell 1989). Isozyme analysis and colony characteristics of isolates of both fungi have shown that this must be excluded. It seems likely that *Ph. spartinicola* has no conidial state, as with many other species of *Phaeosphaeria* (Leuchtmann 1984).

Shoemaker and Babcock (1989) have recently described six new subgenera within the genus *Phaeosphaeria* based on shape and septation of the ascospores. According to our investigations *Ph. spartinicola* fits well in the subgenus *Ovispora* Shoemaker & Babcock. Most authors have viewed the tissue type of the ascomatal wall as an important character to distinguish *Phaeosphaeria* from related genera such as *Leptosphaeria* Ces. & De Not. (e. g. Holm 1957; Leuchtmann 1984). In this regard, *Ph. spartinicola* is a typical *Phaeosphaeria*. *Ph. typharum*, on the other hand, was considered by Leuchtmann (1984) to be an isolated species, because of its reduced ascoma structure, and it was even questioned whether the inclusion of this species into *Phaeosphaeria* is appropriate (Shoemaker and Babcock 1989). Thus, *Ph. spartinicola* and *Ph. typharum* are apparently not as related as the similarity of the ascospore morphology is suggesting.

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NOTES ON CLAVARIADELPHUS. IV.
CULTURAL CHARACTERS OF C. LIGULA AND C. SACHALINENSIS[1]

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SUMMARY

Cultural characters of Clavariadelphus ligula and C. sachalinensis are described. This represents the first report of culture mat analysis of Clavariadelphus.

In an attempt to elucidate supplementary taxonomic data for a systematic treatment of Clavariadelphus, somatic culture mat analyses based on the classic works of Nobles (1948, 1958a, 1965) and Stalpers (1978) were undertaken. Although culture mat analyses are almost routine in studies of wood-rotting Aphyllophorales, such studies are less common with clavarioid basidiomycetous fungi. To date, descriptions of cultures of clavarioid fungi have been largely limited to members of typhuloid groups (Koske, 1975; Koske & Perrin, 1971), pteruloid taxa (McLaughlin & McLaughlin, 1972), Clavicorona (Koske & Leathers, 1969; Dodd, 1972), Ramaria (Petersen, 1972), and Lentaria (Petersen, 1974). Among the factors limiting the application of Nobles' and Stalpers' studies to the clavarioid fungi has been the difficulty in obtaining axenic tissue isolates. In Clavariadelphus, for example, oxidation of tramal tissues on exposure to air often precludes isolation of somatic tissues.

Somatic tissue isolates of Clavariadelphus were obtained following the techniques outlined by Molina & Palmer (1982). Modified Melin-Norkrans Medium (= MMN) plus benomyl (10 mg/l) and streptomycin sulphate (10 mg/l)

[1] This work represents a portion of a dissertation submitted to the Graduate School of The University of Tennessee, Knoxville, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

in disposable glass test tubes (Marx, 1969; Molina & Palmer, 1982) was used for isolation attempts. Six to eight replicates were taken for each collection gathered. The resulting isolates were stored on MMN in the dark at 4 °C and have been deposited in the mycological culture collection at Eastern Illinois University (EIU). Dried voucher material of specimens used to obtain somatic tissue isolates were deposited in The University of Tennessee Herbarium (TENN).

Culture mat analyses were based on the pioneering studies of Nobles (1948, 1965) and Stalpers (1978). Seven replicates of each isolate were inoculated on either MMN, Malt Extract Agar (= MEA; Nobles, 1948) or Difco Potato Dextrose Agar (= PDA; Nobles, 1948) and incubated in the dark at 20-22 °C. Macromorphological descriptions were recorded during the third and sixth weeks. Micromorphological characters were examined and recorded during the sixth week. Micromorphological characters were observed under phase contrast microscopy after mounting hyphae from the advancing zone, mat, and plug of each isolate in 3% potassium hydroxide (KOH). Descriptive terminology was taken from Nobles (1948, 1965) and Mueller (1984). Extracellular oxidase activity of each isolate was tested using both the Bavendamm (Davidson _et_. _al_., 1938) and gum guaiac (Nobles 1958b) tests. Spot tests for the presence or absence of laccase and tyrosinase were performed on all isolates. The following substrate-specific reagents were used: 1) For laccase: syringaldazine (Harkin & Obst, 1973; Harkin _et_. _al_., 1974); 2) For tyrosinase: L-tyrosine (Marr, 1979). Control spot tests with distilled water and 95% ethanol were also performed on all isolates. Color terms followed by alphanumeric designations are from Kornerup and Wanscher (1978). Herbarium acronyms are from Holmgren _et_. _al_. (1981).

Clavariadelphus _ligula_ (L.: Fr.) Donk Figs. 1-4

Isolates: _Idaho_. Bonner Co., Priest Lake, 29.ix.1984, Methven No. 3306; Bonner Co., Priest Lake, 26-27.ix.1986, Methven No. 4989. _New_ _York_. Wayne Co., Rochester, 14.viii.1986, Methven No. 4713. _Oregon_. Clackamas Co., Mt Hood National Forest, 20.x.1984, Methven No. 3518. _Washington_. Chelan Co., vicinity of Lake Wenatchee, 15.x.1984, Methven No. 3525. (all TENN).

Nobles Code: 1.3.22.(26).34.36.47.51.56.

Macromorphology (n = 5): **PDA:** Radius at week III 14-18 mm, week VI 28-32 mm; mat thin, appressed, tightly interwoven, initially chamois-like, in time farinaceous to subfelty, not translucent, initially white to pallid, finally yellowish white (3A2, 4A2) to cream (4A3); margin 3-5 mm broad, thin, submerged, uneven, semi-translucent, initially white to pallid, finally yellowish white (3A2, 4A2); plug soon farinaceous to subfelty, concolorous with mat. **MMN:** Radius at week III 18-24 mm, week VI 30-38 mm; mat thin, appressed, tightly interwoven, initially chamois-like, in time farinaceous to subfelty, not translucent, initially white to pallid, finally yellowish white (3A2); margin 7-10 mm broad, submerged, thin, uneven, semi-translucent, white to pallid; plug soon farinaceous to subfelty, concolorous with mat. **MEA:** Radius at week III 20-25 mm, week VI 55-65 mm; mat thin, appressed, tightly interwoven, initially chamois-like, in time farinaceous to subfelty, not translucent, white to pallid; margin 3-5 mm broad, thin, submerged, uneven, semi-transparent, concolorous with mat; plug soon farinaceous to subfelty, concolorous with mat.

Extracellular Oxidase Reactions: Gallic and tannic acid agar and L-tyrosine negative. Some isolates were weakly positive for gum guaiac while others were negative. Syringaldazine positive.

Micromorphology (n = 5): **PDA:** Hyphae mostly undifferentiated with scattered, irregular, coralloid to subcoralloid branches, clamped, uninflated or irregularly inflated (- 10 µm); walls thin or irregularly thickened to 1 µm, smooth or encrusted with irregularly angular-shaped crystals; clamps uninflated or inflated (-8 µm), sometimes medallion or ampulliform; vesicles few to many, intercalary or terminal. **MMN:** Hyphae as in PDA; vesicles as in PDA. **MEA:** Hyphae as in PDA; vesicles as in PDA.

Clavariadelphus sachalinensis (Imai) Corner

Isolates: Idaho. Bonner Co., Priest Lake, 26-27.ix.1986, Methven No. 4983. Washington. Kittitas Co., Stampede Pass, 9.x.1984, Methven No. 3445; Kittitas Co., Crystal Springs, 12.x.1984, Methven No. 3490; Stevens Co., Highway 20, 26.ix.1986, Methven No. 4985. (all TENN).

Nobles Code: 2.3.22.(26).34.36.47.51.56.

Macromorphology (n = 4): **PDA**: Radius at week III < 1 mm, week VI 1-2 mm; mat thick, appressed, tightly interwoven, felty, not translucent, greyish orange (5B4-3) to brownish orange (5C4-3); margin indistinct from mat, submerged, uneven, not translucent, concolorous with mat; plug soon felty, concolorous with mat. **MMN**: Radius at week III 5-8 mm, week VI 12-15 mm; mat thin, appressed, tightly interwoven, initially chamois-like, soon farinaceous to subfelty, not translucent, initially pallid to cream (4A3-2), finally brownish orange (5C3-2, 6C3-2); margin 3-6 mm broad, thin, submerged, uneven, semi-translucent, initially concolorous with mat, finally greyish brown (5E3-2) to brownish beige (6E3-2); plug soon subfelty to felty, concolorous with mat. **MEA**: Radius at week III 8-12 mm, week VI 18-21 mm; mat thin, appressed, tightly interwoven, initially chamois-like, in time subfelty to felty, not translucent, white to pallid; margin 3-5 mm broad, thin, submerged, uneven, semi-translucent, concolorous with mat or paler; plug soon subfelty to felty, initially concolorous with mat, in time greyish orange (5B3) to orange-grey (5B2).

Extracellular Oxidase Reactions: Gallic and tannic acid agar and syringaldazine positive. Gum guaiac weakly positive. L-tyrosine negative.

Micromorphology (n = 4): **PDA**: Hyphae mostly undifferentiated with scattered, irregular, coralloid to subcoralloid branches, clamped, uninflated or irregularly inflated (- 10 μm); walls thin or irregularly thickened to 1 μm, smooth or encrusted with irregularly angular-shaped crystals; clamps uninflated or inflated (-8 μm), sometimes medallion or ampulliform; vesicles few to many, intercalary or terminal. **MMN**: Hyphae as in PDA; vesicles as in PDA. **MEA**: Hyphae as in PDA; vesicles as in PDA.

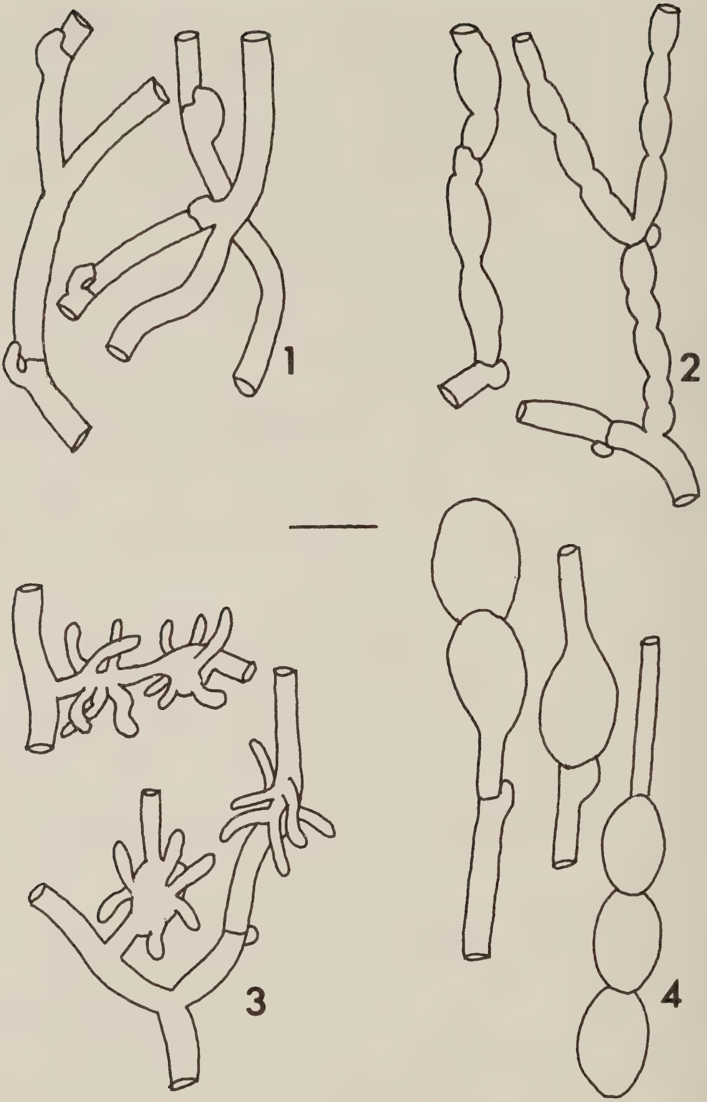
DISCUSSION

The most diagnostic characters exhibited by the cultures during this study were growth rate (expressed as the radius of the culture mat at week III and week VI) and color of the culture mat. During a six week period, cultures of *Clavariadelphus sachalinensis* grew slowly on all three media (MEA: 18-21 mm; MMN: 10-15 mm; PDA: 1-2 mm). On the other hand, cultures of *Clavariadelphus ligula* exhibited moderate growth rates on all three media (MEA: 55-65 mm; MMN: 30-38 mm; PDA: 28-32 mm) over the same six week period. As such, differences in growth rates, especially on PDA, appears to be useful as a taxonomic character for delimiting cultures of *Clavariadelphus ligula* and *C. sachalinensis*.

The color of the culture mat is of limited taxonomic importance. On MEA, the cultures of *Clavariadelphus ligula* and *C. sachalinensis* were white to pallid. After six weeks of growth on MMN, however, the cultures of *Clavariadelphus ligula* were white to pallid, while the isolates on PDA were pale yellow or cream colored. On the other hand, the cultures of *Clavariadelphus sachalinensis* on PDA and MMN were greyish orange to brownish orange after six weeks of growth. Although a slight bleaching of color was often observed on the reverse side of the culture, no significant color changes were recorded during the period of study.

Except for a thin, chamois-like, farinaceous or subfelty layer on the plug and surrounding mycelial mat, the cultures exhibited largely submerged growth on all three media. The mat was thickest near the inoculation plug and thinner at the margin of growth. Growth of the isolates was more or less uniform, the mycelial mat did not exhibit sectoring, produce concentric bands, become furrowed or yield exudates. All isolates produced a similar earthy or musky odor on each of the three media.

No growth was exhibited by any of the isolates grown on gallic and tannic acid agar. Although cultures of *Clavariadelphus ligula* did not yield a diffusion zone on gallic and tannic acid agar, isolates of *C. sachalinensis* produced a dark brown diffusion zone on both media in less than seven days. The results of the gum guaiac test (Nobles, 1958a) were inconclusive. Nobles (1958a) stated that positive tests for extracellular oxidases must be immediate. In each of the isolates tested, the reaction took 15-30 minutes to develop and was at most weakly positive. Syringaldazine and L-tyrosine were applied directly to the surface of the culture mats of each of the isolates to test for the presence of the laccase and tyrosinase enzyme systems, respectively. In each isolate, syringaldazine produced a magenta color reaction when



Figs. 1-4. *Clavariadelphus ligula*. Fig. 1. Undifferentiated hyphae. Fig. 2. Irregularly swollen hyphae. Fig. 3. Coralloid hyphae. Fig. 4. Hyphal swellings. Scale bar = 20 µm.

applied to the cultures of *Clavariadelphus ligula* and *C. sachalinensis* indicating the presence of the laccase enzyme system. The L-tyrosine spot tests were negative.

Although it was expected that micromorphological culture characters might be as diagnostic as macromorphological characters (Nobles 1948, 1965), this is not the case in *Clavariadelphus*. As seen in Figs. 1-4, little hyphal differentiation was observed in the isolates. In each isolate, the vast majority of the hyphae were thin-walled, clamped and undifferentiated (Fig. 1) with the exception of scattered, irregularly swollen or inflated hyphae (Fig. 2) and subcoralloid to coralloid hyphal branches (Fig. 3). Simple swellings on the hyphae (Fig. 4), which were observed in intercalary or terminal chains of 1-3 (4) in each of the isolates, may have been induced as the hyphae matured or by the medium upon which they grew (Hutchinson, 1989). They do not fit the definition of chlamydospores described by Hawksworth *et*. *al*. (1983) or Hughes (1985).

In terrestrial ecosystems, the basidiocarps of *Clavariadelphus ligula* and *C. sachalinensis* arise from a well-developed mycelial mat in which the hyphae are densely interwoven and often bind large patches of the substratum to the basidiocarp base (Methven, 1990). Although this growth habit suggests that members of *Subg*. Ligulus are saprobic (Petersen, *pers*. *comm*.), the genus *Clavariadelphus* is generally presumed to be ectomycorrhizal. The cultural data gathered in this study supports the assumption that the genus is ectomycorrhizal. Of particular relevance are the following characters which are shared with known ectomycorrhizal taxa: 1) production of few micromorphological structures in culture which are useful in identification (Hutchinson, 1989); 2) partial or total inhibition of basidiospore germination *in vitro* (Methven, unpublished data); 3) tendency toward slow growth in axenic cultures; 4) lack of conidial anamorphs *in vitro* (Hutchinson, 1989); and 5) a general absence of basidiocarp formation in agar culture (Pantidou *et*. *al*., 1983). In order to clarify their ecological classification, cultures of *Clavariadelphus ligula* and *C. sachalinensis* should be tested for their ability to form ectomycorrhizae.

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ICONES ASCOMYCETUM VENEZUELAE:

PHYLLACHORA FUSICARPA

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ABSTRACT

A perithecial ascomycete growing on living leaves of *Duranta repens* was identified as *Phyllachora fusicarpa* Seaver, cause of tar spot disease. The fungus forms lesions with a raised, shiny black clypeus surrounded by a yellow halo; spermogonia and perithecia are formed in the lesions. The Venezuelan collections were compared with specimens of *P. durantae*, which also occurs on *Duranta* sp. The two fungi are similar but differ sufficiently in ascospore length that they are retained as separate species. An illustrated description of the Venezuelan material is provided, along with notes on *P. durantae*.

Keywords: Ascomycotina, *Duranta* spp., *Phyllachora durantae*, Phyllachoraceae, tar spot disease.

RESUMEN

Un ascomiceto peritecial creciendo sobre hojas vivas de *Duranta repens* se identificó como *Phyllachora fusicarpa*

Seaver, agente causal de la enfermedad alquitranada. El hongo produce lesiones levantadas, con un clípeo negro brillante, rodeado por un halo amarillo y en ellas se forman espermogonios y peritecios. Las coleciones venezolanas se compararon con especímenes de *P. durantae* que tambien ocurre en *Duranta* sp. Los dos hongos son similares, pero la diferencia significativa que tienen en la longitud de las ascosporas hace que sean colocados en especies separadas. Se provee una descripción ilustrada del material venezolano, además de notas sobre *P. durantae*.

INTRODUCTION

Duranta repens L. (garbancillo, chinchorro, fruta de paloma, limoncillo) is a verbenaceous shrub native to the American tropics. In Venezuela it occurs in the wild, but it is also used as a hedge planting (Schnee, 1973). While collecting plant pathogenic fungi in northern Venezuela, leaves of *D. repens* bearing lesions with black ascomata were encountered. The fungus was subsequently identified as *Phyllachora fusicarpa* Seaver (Dennis, 1970), cause of tar spot disease. In describing *P. fusicarpa* as new, Seaver (1920) stated that it differed from the similar *P. durantae* Rehm in ascospore size. *Phyllachora durantae*, which also occurs on *Duranta* sp., was described by Rehm (1892) from material collected in Ecuador by Lagerheim. Since it seemed possible that the two species could be conspecific, the type material of both species was examined and compared with the Venezuelan collections. The results of this study are presented below, along with an illustrated description of the Venezuelan material.

MATERIALS AND METHODS

Observations were made on living material collected in the field and on herbarium specimens; herbarium acronyms follow Holmgren *et al.* (1981). Sections were made of living material to provide additional information. Material to be sectioned was killed and fixed in formalin-propionic acid-alcohol (FPA) and embedded in paraffin, following procedures described previously (Hanlin and Tortolero, 1989). Herbarium material was softened in water prior to mounting. Measurements were made of 25 paraphyses, asci, ascospores, and spermatia mounted in water, and of 10 perithecia and spermogonia in sectioned material. Not all structures were available for measurement in the type material. Photographs were taken with a Nikon HFX camera on a Nikon SMZ stereo microscope or an Optiphot equipped with Nomarski differential interference contrast. Kodak Technical Pan 2415 film was used for photography.

OBSERVATIONS

Examination of the holotype specimens of *P. durantae* and *P. fusicarpa* revealed that the two species are identical in appearance, but the difference in length of the ascospores could not be confirmed, as no asci were found in the type material of *P. fusicarpa*. Leaf lesions yielded spermatia, but no asci or ascospores. A microscope slide included in the type packet was dried and of no value. Asci and ascospores were present in the type of *P. durantae* and the size of the ascospores agreed with the published data. Spermogonia were common in the type of *P. fusicarpa*, although they were not mentioned by Seaver in his description. None were found in the type of *P. durantae*, perhaps due to the sparseness of the material.

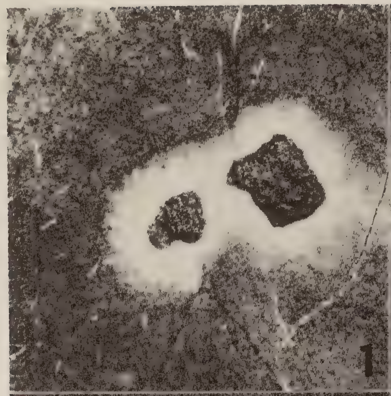
Phyllachora fusicarpa **Seaver**

Anamorph: Lacking.

Mycelium internal, forming amphigenous lesions on living leaves. Young lesions chlorotic, with upper surface becoming light green and flat, lower surface white and raised. Mature lesions circular to irregular in outline, (3.5)-4-(8) mm in diameter, thicker than normal leaf, black, with yellow halo (Figs. 3-4). Spermogonia formed in young lesions, followed by perithecia in older lesions.

Spermogonia subepidermal, mostly epiphyllous, raised, pulvinate, (111)-183-(237) μm high X (348)-555-(909) μm wide, formed beneath a shiny black clypeus, varying in shape from circular to elongate in top view, opening by a pore or slit (Fig. 5). Base of spermogonium delimited by a region of compact hyphae with dark brown walls. Spermatiogenic cells forming a crowded layer across bottom of spermogoniun inside dark-walled hyphae, one-celled, cylindrical to slightly fusoid, sometimes curved, (13)-17-(24) X (2)-3-(4) μm, tapering to a slender tip, extruding spermatia from apex (Fig. 7). Spermatia one-celled, fusiform, often slightly curved (Fig. 6), (8)-10.4-(24) X (2)-2.7-(4) μm, with a small lipid droplet at each end, hyaline, often extruded from pore in a yellowish cirrhus.

Figs. 1-7. *Phyllachora fusicarpa* on *Duranta repens*. Fig. 1. Mature lesions on upper surface of leaf from holotype. X24. Fig. 2. Same lesions on lower surface of leaf. X24. Fig. 3. Mature lesion on upper surface of leaf from Venezuelan collection. X14. Fig. 4. Same lesion on lower surface of leaf. X14. Fig. 5. Section through spermogonium on lower surface of leaf. X158. Fig. 6. Mature spermatia. X2050. Fig. 7. Spermatiogenic cell with spermatium attached at apex. X1900.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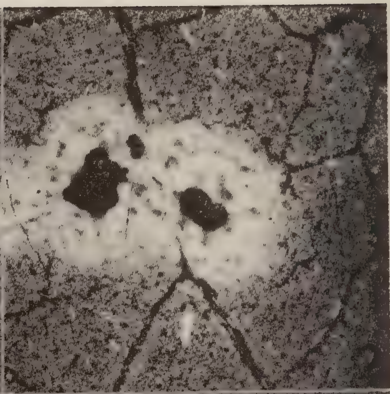

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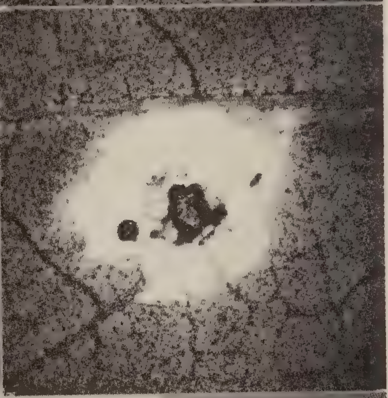

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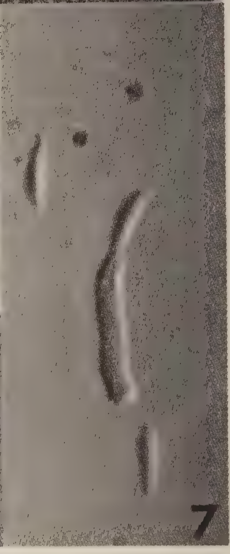
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Ascoma an ostiolate perithecium, immersed in leaf tissue, usually hypophyllous, formed beneath a blackened clypeus, with erumpent ostiolar neck (Fig. 8). Perithecium subglobose to oval or obpyriform, (308)-376-(490) μm high X (316)-407-(529) μm wide. Perithecial wall brown, (16)-19-(24) μm wide, outer cells initially pseudoparenchymatous and dark brown, becoming flattened and thicker-walled, inner cells hyaline, flattened, and thin-walled. Centrum containing abundant septate, filiform paraphyses (Fig. 9). Asci unitunicate, (70)-105-(140) X (12)-17-(24) μm, formed in a basal layer, growing up among the paraphyses, ellipsoid, short-stalked (Fig. 11), with a non-amyloid apical ring, eight-spored. Ascospores hyaline, one-celled, broadly fusoid, (22)-30-(40) X (7)-8.6-(10) μm, smooth (Fig. 10).

Occurring on living leaves of *Duranta repens*.

Etymology: *fusicarpa* = Latin, fuscus (spindle) + Greek, carpus (fruit), referring to the shape of the ascospores.

Specimens examined: BAHAMAS: On *Duranta repens*: F. S. Earle (#36), Nassau, undated (NY, TYPE); **VENEZUELA:** On *Duranta repens*: M. F. Burrico & A. S. Muller, Sanare, Edo. Lara, November 24, 1939 (VIA 3642); A. S. Muller, Los Choros, Edo. Miranda, January 20, 1939 (VIA 2364); O. Tortolero & R. T. Hanlin (#606), Sanare, Edo. Lara, January 24, 1984; O. Tortolero, Sanare, Edo. Lara, 1984; O. Tortolero & R. T. Hanlin (#764), Sanare, Edo. Lara, February 11, 1987 (GAM 12760); O. Tortolero & R. T. Hanlin (#820), Sanare, Edo. Lara, February 11, 1988 (GAM 12755); O. Tortolero, Sanare, Edo. Lara, April 12, 1988; O. Tortolero & R. T. Hanlin (#830), Bojo, Edo. Lara, April 26, 1988; Y. O. Mercado, Bojo, Edo. Lara, July 25, 1988 (GAM 12757); R. T. Hanlin (#875) & O. Tortolero, Las Lajitas, Edo. Lara, December 13, 1988 (GAM 12758); R. T. Hanlin (#918) & Y. O. Mercado, Las Lajitas, Edo. Lara, November 8, 1989 (GAM 12756).

Most of the collections were made at ca. 1000 m.

Since *P. durantae* appears not to have been described in English, a translation of the original description follows, with some supplemental notes.

Figs. 8-11. *Phyllachora fusicarpa* on *Duranta repens* from Venezuela. Fig. 8. Section through mature perithecium immersed in leaf. X64. Fig. 9. Cluster of paraphyses. Nomarski. X475. Fig. 10. Mature ascospores. Nomarski. X1200. Fig. 11. Ascus with ascospores. X600. Fig. 12-14. Holotype of *Phyllachora durantae* on *Duranta* sp. Fig. 12. Lesions on upper surface of leaf. X37. Fig. 13. Same lesions on lower surface of leaf. X37. Fig. 14. Mature ascus with ascospores. X750.

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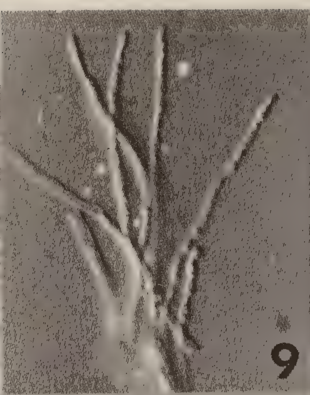
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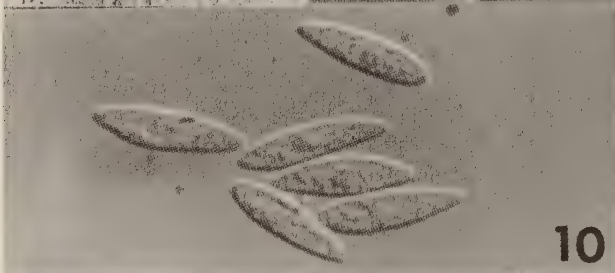
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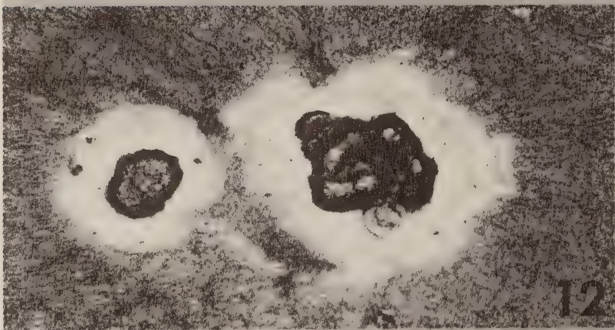
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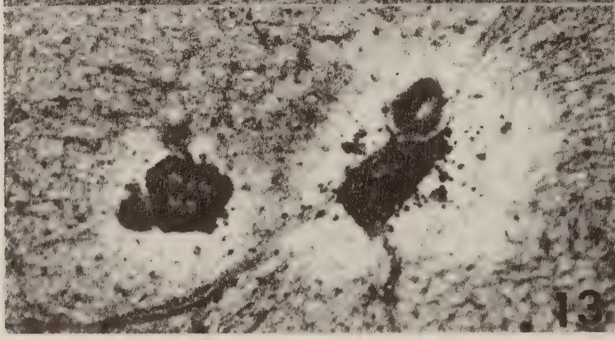
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Phyllachora durantae **Rehm**

Anamorph: None reported.

"Stromata immersed on both sides of surface, almost round, irregularly raised, membrane of leaf yellowish, yellow-white inside, 0.5-2 mm wide encircling the stroma, shiny, black, 1-3 mm diam. Perithecia mostly 12, immersed, protuberant, scarcely papillate and not perforate. Asci fusiform, stipitate, apex acute, 90 X 21, 8-spored. Spores elliptical, 1-celled, filled with oil droplets, weakly yellowish, 15 X 8, distichous. Paraphyses branched, hyaline".

Occurring on living leaves of *Duranta* sp.

Etymology: *durantae* = Latin, for the host genus.

Specimens examined: ECUADOR: On *Duranta* sp.: G. Lagerheim (#1075), Quito, April, 1892 (S, TYPE); on *D. benthami* Briq.: H. Sydow (#1177), Pichincha, September 12, 1937 (S).

Both collections of *P. durantae* were identical to each other and to *P. fusicarpa* (Figs. 1-2), except for the smaller size of the asci and ascospores of *P. durantae*. The prominent yellow halo typical of *P. fusicarpa* was apparent even in dried specimens of *P. durantae* (Figs. 12-13). Size ranges obtained for *P. durantae* were (76)-97-(122) X (14)-22-(32) for asci (Fig. 14) and (16)-19-(22) X (8)-9-(10) for ascospores, which agrees well with Rehm's original figures.

DISCUSSION

On the basis of Seaver's original description, the ranges in ascospore length do not overlap in the two species; in *P. durantae* the length:width ratio is 1:2.1, whereas in *P. fusicarpa* it is 1:3.2. In ascospore width the two species are identical. The Venezuelan collections agree closely with *P. fusicarpa*, and they are therefore considered to be that species. Although Seaver did not provide a Latin description for *P. fusicarpa*, the name was published before 1935 and is therefore legitimate (Art. 36.1; Greuter, 1988).

Given the similarities in morphology, hosts, and geographical distribution, it seems unlikely that *P. durantae* and *P. fusicarpa* are truly distinct species. The difference in ascospore length may well be due to differences in host and/or geography. *Phyllachora fusicarpa* grows at low altitudes, whereas *P. durantae* was collected above 3,000 m. Little is known of the effects of such factors on spore size and other morphological characteristics, but it may be that a smaller ascospore is an adaption to dispersal in less dense air. It also may be that the differences are an artifact of sample size. In any event, in the absence of more data, and since the two taxa are readily separated on ascospore size, it seems preferable to retain them as separate species until more is known about their biology.

Phyllachora fusicarpa has been reported from the Bahamas (Seaver, 1920), Haiti (Diehl, 1942), Puerto Rico (Seaver and Chardon, 1926), the United States (Florida) (Diehl, 1942), and Venezuela (Chardon and Toro, 1934). The host is *Duranta repens*, except in Haiti, where it occurs on *D. erecta* L.; in the Florida collection the host species is unknown. *Phyllachora durantae* apparently has been reported only on *D. benthami* from Ecuador.

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NEOTYPIFICATION OF LEPTOSPHAERULINA CRASSIASCA

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ABSTRACT

Leptosphaerulina crassiasca, the causal agent of pepper spot and leaf scorch diseases of peanut, is a common pathogen of this crop in Georgia and other peanut growing areas of the world. Although the fungus has been well characterized taxonomically, there appears to be no extant authentic or type material. Neotype material is therefore designated, and an illustrated description of it is provided. Cultural characteristics of the neotype isolate are also described.

Keywords: *Arachis hypogaea*, Ascomycotina, Dothideales, leaf scorch, *Leptosphaerulina arachidicola*, Loculoascomycetes, pepper spot, *Pleospora crassiasca*.

INTRODUCTION

While conducting mycofloral studies of peanut (*Arachis hypogaea* L.) (Hanlin, 1969), an ascomycete was obtained that was subsequently identified as *Leptosphaerulina crassiasca* (Sechet) Jackson & Bell (Hanlin, 1973). This is a common pathogen of peanut, on which it causes pepper spot and leaf scorch diseases, but the symptoms are often obscured by other foliar fungal pathogens, such as the early and late leaf spots (Young *et al.*, 1980; Smith, 1984). Luttrell and Boyle (1960) reported that this fungus was first found in Georgia in 1958, but they also pointed out that its common occurrence throughout the peanut belt indicated that it had been in the United States for many years. Although the taxonomic characteristics of *L. crassiasca* have been described previously (Luttrell and Boyle, 1960; Graham and Luttrell, 1961; Jackson and Bell, 1969), it was discovered that no authentic or type herbarium material exists for this species. Consequently, neotype material is designated and an illustrated description is provided.

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MATERIALS AND METHODS

Five isolates of *L. crassiasca* from peanut were examined during this study. The sources and taxonomic characteristics of these isolates are shown in Table 1. All isolates were stored on 18% V-8 vegetable juice agar (V8) at 4C during the studies. After preliminary observations, isolate P3480 was selected for further studies on growth characteristics and ascomal development. Growth studies were conducted on V8 and malt extract (MEA) agars (Hanlin and Ulloa, 1988) in an incubator at 26C under constant fluorescent ("Daylight") light ca. 12 cm above the petri plates. The effects of light on growth and ascospore discharge were ascertained by wrapping petri plates with aluminum foil following inoculation or by covering a portion of the petri plate lid with black construction paper. These plates were then placed in the incubator alongside unmodified check plates. Taxonomic observations were made both on fresh and sectioned material from culture and on the host. Measurements were made on material mounted in water and in paraffin sections. Ascomata on the host were obtained by placing peanut leaflets bearing symptoms of pepper spot in a moist chamber for 48 hr to permit their development. The infected leaflets were derived from plants of cv. Tamnut that had been artificially inoculated in the greenhouse with isolate P3480. Reisolations were made from infected leaflets by surface disinfecting them in a bleach-ethanol-water solution (10:10:80) (Hanlin, 1969) and plating them on V8 agar. Material to be sectioned was cut into 5 mm^2 blocks, fixed in formalin-propionic acid-alcohol, dehydrated through a tertiary butyl alcohol series, embedded in paraplast, sectioned at 8 μm, mounted on standard glass slides, deparaffined, rehydrated through an ethanol-water series, stained in iron hematoxylin, then destained in a saturated aqueous solution of picric acid (Johansen, 1940). The stained sections were dehydrated through a water-ethanol series to xylene, and a cover slip was mounted with Permount. Measurements were made of 25 ascostromata, asci, and ascospores; sizes given represent the averages of these measurements. Photographs were taken with a Nikon HFX camera on a Nikon SMZ stereo microscope or a Nikon Optiphot equipped with Nomarski differential interference contrast. Kodak Technical Pan 2415 film was used for photography.

Herbarium material of the isolates studied was prepared by growing them on V8 on which small sections of bean stem (*Phaseolus vulgaris* var. *humulis* Alef.)

had been placed. When mature ascospores were present the petri plates were preserved by freeze-drying (Hanlin, 1972). Herbarium acronyms follow Holmgren *et al.* (1981).

OBSERVATIONS

Observations on the Florida and Georgia isolates of *L. crassiasca* demonstrated that they were very similar in their taxonomic characteristics (Table 1). Visually they showed only small differences in the amount of aerial mycelium produced on V8. The Taiwan isolate, however, varied from the others in several respects, which are described in more detail below. *Leptosphaerulina crassiasca* was recovered readily from leaflets inoculated with isolate P3480, and ascomata also formed abundantly on leaflets placed in a damp chamber. On the basis of these preliminary observations, isolate P3480 was selected as representative of the species. A detailed description of this isolate, which is designated as the neotype, follows.

Leptosphaerulina crassiasca **(Sechet) C. R. Jackson & D. K. Bell** (Jackson and Bell, 1968)
≡*Pleospora crassiasca* Sechet (Sechet, 1955)
=*Leptosphaerulina arachidicola* J. Yen, Chen & K. Huang (Yen *et al.*, 1956)

Anamorph: None reported.

On host:

Mycelium internal, hyphae (4)-6-(10) μm in diameter, forming lesions on leaves. Lesions of two distinct types; in one type, the lesions first appear as sunken, oval to irregular, slightly chlorotic flecks, ca. 0.5 mm wide, scattered on leaflet. Older lesions reddish-brown to brown in center, with light yellow halo, up to 1 mm wide, sometimes coalescing, becoming brown to black when mature. Lesions occurring on both sides of leaflet, but adaxial lesions more frequent. The second type of lesion occurs as a broad necrotic area that may form on leaflet margin or as a wedge-shaped tip lesion that develops along the midrib toward the petiole.

Ascoma an ostiolate pseudothecium, solitary, scattered, immersed in tissue of leafspot (Fig. 4), formed in fallen leaves. Pseudothecia dark brown to black, subglobose to broadly oval or obpyriform, glabrous, (76)-99-(146) μm high X (70)-86-(126) μm wide, with an erumpent, papillate, ostiolar neck, usually epiphyllous. Pseudothecial wall 10-12 μm wide, composed of angular to somewhat elongated cells with pigmented walls, cells at apex and around ostiolar neck darker brown. Paraphyses lacking, but remnants of crushed centrum tissue may occur between the asci. Asci 3-18 in number, completely filling the locule when mature. Asci initially clavate, then saccate or ovoid to broadly obclavate, bitunicate (fissitunicate), with inner wall layer greatly thickened at apex and becoming thinner along sides and base, (30)-46-(60) μm long X (12)- 27-(40) μm wide, 8-spored. Ascospores in an irregular cluster in ascus, muriform or sometimes phragmosporous, with 3-5 transverse and 0-2 longitudinal septa, oval to oblong or ellipsoid and slightly constricted at the septa, (20)-24-(26) μm long X (4)-8-(10) μm wide, surrounded by a thin gelatinous sheath, hyaline when mature, becoming yellowish to light brown upon discharge.

In culture:

On V8: Colony hyaline when young, barely visible, hyphae appressed to agar surface, becoming black with development of pseudothecia, sectors of colony sometimes becoming covered with a flat, felt-like layer of white aerial hyphae. Colony diameter from single spores 3-5 mm after 2 days and 16-18 mm after 3 days. Vegetative hyphae hyaline, thin-walled, 2-8 μm wide; fertile hyphae darker and wider than vegetative hyphae, 8-18 μm in width, thicker walled, usually septate at shorter intervals, becoming inflated and frequently strongly constricted at the septa. Pseudothecia with mature ascospores present after 3 days. Pseudothecia solitary and scattered or sometimes aggregated in small clusters (Fig. 1), partially to entirely immersed in agar, subglobose to broadly oval or obpyriform, glabrous, (90)-135-(180) μm high x (82)-127-(180) μm wide, lightly pigmented with translucent walls when young, appearing black when mature, with a broad pore in a raised ostiolar neck (Fig. 2). Pseudothecial wall 8-10 μm thick; wall cells angular to oblong (Fig. 3), with slightly thickened walls, dark brown when mature, cells around base of ostiolar neck black, forming a distinct ring. Ostiolar neck papillate to elongate, composed of subhyaline cells. Paraphyses lacking, but remnants of centrum tissue may occur between asci. Asci clavate when young (Fig. 8), becoming saccate or ovoid to broadly obclavate (Fig. 9), (58)-71-(84) μm high x (30)-42-(52) μm wide, 8-spored, bitunicate (fissitunicate), the inner wall layer (endotunica) rupturing through the outer wall layer (ectotunica) of the ascus as a cylindrical extension when mounted in water (Fig. 10). Ascospores arranged in an irregular cluster in ascus, usually muriform (Fig. 5), but some phragmosporous (Fig. 7), containing 3-5 transverse and 0-2 longitudinal septa, oblong to ellipsoid, often

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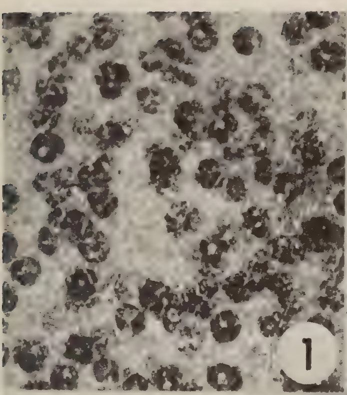
Figs. 1-7. Neotype of *Leptosphaerulina crassiasca*. Fig. 1. Pseudothecia on V8 agar. X74. Fig. 2. Close-up of pseudothecium grown on V8 agar. X294. Fig. 3. Wall cells of pseudothecium. X450. Fig. 4. Section through mature pseudothecium in peanut leaflet. X431. Fig. 5. Muriform ascospores. X1364. Fig. 6. Ascospore with gelatinous sheath. (Nomarski) X1300. Fig. 7. Phragmosporous ascospore. X1400. Fig. 8. Young bitunicate ascus. X1250. Fig. 9. Mature bitunicate ascus with ascospores. X1000. Fig. 10. Bitunicate ascus with expanded endotunica. The apex of the ectotunica is indicated by the arrow. X653.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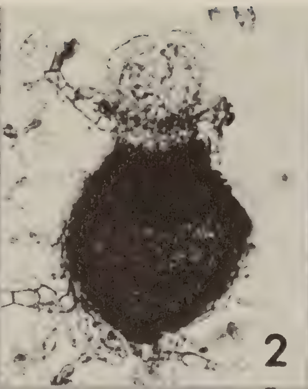
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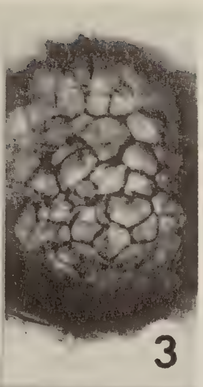
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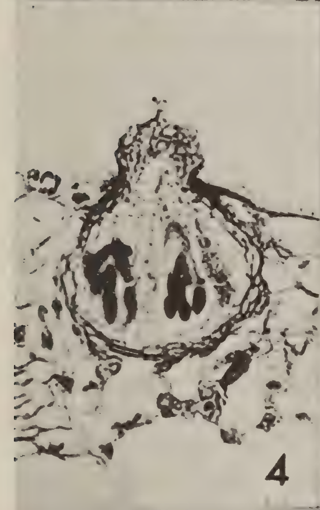
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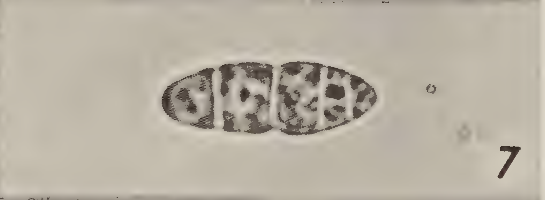
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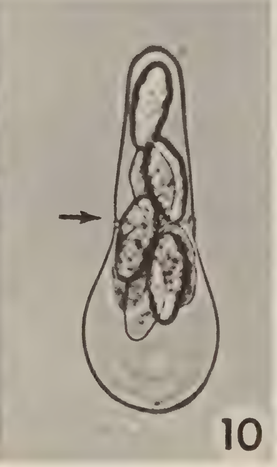
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widest above the middle, rounded at the top and tapering toward the bottom, slightly constricted at the septa, (28)-33-(38) μm long x (10)-15-(20) μm wide, surrounded by a thin gelatinous sheath (Fig. 6), hyaline when mature, becoming light brown upon release.

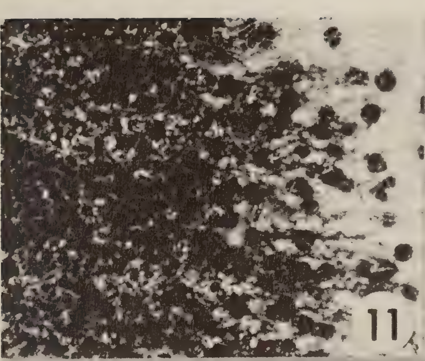
On MEA: Colony development as on V8 agar, but fertile hyphae quickly become darkly pigmented, forming an opaque colony with a flat, shiny black surface that may become partly covered by a flat layer of gray aerial hyphae (Fig. 11). Pseudothecia scattered or in small clusters, (132)-175-(240) μm high X (84)-130-(180) μm wide. Wall cells of pseudothecia soon becoming black and opaque. Asci (54)-67-(80) X (24)-37-(44) μm, formed as on V8, but maturing more slowly, with many immature after one week. Ascospores as on V8, (26)-27-(32) long X (10)-11-(14) μm wide, hyaline while in ascus, but quickly becoming dark brown upon discharge, mostly dictyosporous, but phragmospores common.

Etymology: *crassiasca* = Latin, crassus (thick) + Greek, asci (bag or bladder), referring to the broad ascus.

On living leaves and fruits of *Arachis hypogaea* L., Spalding County, Georgia, U.S.A, R. T. Hanlin (P3480), July 13, 1966. Neotype in GAM (#12761); isoneotype in BPI.

Materials examined. On *Arachis hypogaea*. **TAIWAN:** K. T. Huang (ATCC 13446), December, 1955 (as *L. arachidicola*)(GAM 12765). **UNITED STATES: FLORIDA:** F. M. Shokes (ESL-9345), September, 1980 (as *L. arachidicola*)(GAM 12764); **GEORGIA:** R. T. Hanlin (P3480), Spalding Co., July 13, 1966 (as *L. arachidicola*)(GAM 12761); R. T. Hanlin (P3975), September 26, 1966 (as *L. arachidicola*)(GAM 12762); E. S. Luttrell (#9389), April 22, 1981 (as *L. arachidicola*)(GAM 12763).

Figs. 11-16. Neotype of *Leptosphaerulina crassiasca*. Fig. 11. Portion of colony on MEA. Note dark mycelium, obscuring pseudothecia. X59. Fig. 12. Portion of colony on V8. Individual pseudothecia readily discernible. X56. Fig. 13. Colony on V8 grown under continuous light. Left, left half of petri plate was covered with opaque black paper. Right, cover from petri plate on left. Note lack of ascospore discharge in covered portion of plate. X0.4. Fig. 14. Ascospore mounted in water to which India ink was added to show expanded sheath. The apparent uneveness in sheath thickness is an artifact caused by ink particles flowing over edge of sheath as it flows into mount. X694. Fig. 15. Endotunica with ascospore protruding from ostiole of pseudothecium. X1200. Fig. 16. Pigmented ascospore with germ tubes. X1150.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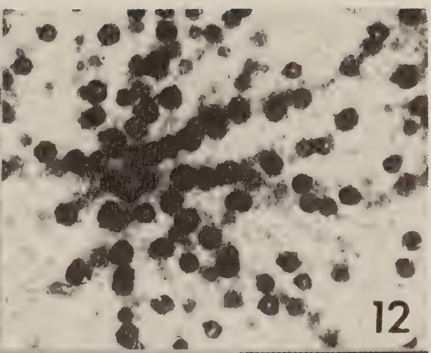
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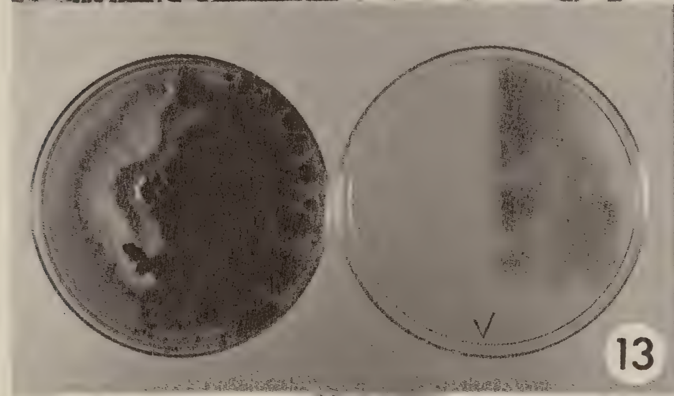
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Taiwan isolate. On V8. Hyphae growing outward as a continuous colony, attaining a diameter of 8 cm after two weeks. Mycelium dark, appressed to surface of agar, forming a pellicle-like layer, bearing numerous pseudothecia. Basal mycelium covered by a white, cottony aerial mycelium that partially obscures the pseudothecia. Colony reverse dark, giving grayish aspect to aerial mycelium. Pseudothecia as in other isolates, but maturing more erratically. Some pseudothecia have mature ascospores in four days, but in others the asci mature more slowly. Forcible discharge of ascospores limited; most ascospores collect in a mass at mouth of ostiole. Discharged ascospores remain hyaline or become only lightly pigmented and are not visible on petri plate lid. Ascospore discharge was effected by extension of the endotunica through the ostiole (Fig. 15). When placed in water, the gelatinous sheath surrounding the ascospores expanded considerably (Fig. 14) and ascospores were capable of germination immediately upon discharge (Fig. 16).

On MEA. Hyphae growing outward as a single colony, reaching 9 cm after two weeks. Colony similar to that on V8, except that the aerial mycelium forms a thick, flat, white, felt-like layer that completely obscures the pseudothecia. Colony reverse black. Forcible ascospore discharge very limited, but ascospores become more darkly pigmented than on V8. Most ascospores collect at the mouth of ostiole.

Neotype isolate. When grown in continuous light, colony diameter on agar rarely exceeded 2 cm, as growth ceased with maturation of the pseudothecia. Subsequent development of colonies in the periphery of the petri plate from discharged ascospores filled the plate within one week.

The difference in appearance of colonies on V8 and MEA is striking. On V8 the pigmented hyphae are subhyaline or light brown and the colony remains translucent, with distinct light areas between the pseudothecia (Fig. 12). On MEA, however, the intense pigmentation of the fertile hyphae results in a black, opaque colony in which individual pseudothecia can be distinguished only at the lighter margins of the colony (Fig. 11). Ascospore discharge onto the petri plate lid appears reduced on MEA compared to V8 and the discharged ascospores quickly become dark brown. Pigmentation also occurs in discharged ascospores produced on V8, but it is lighter and slower to develop. Another difference between the two media is the ratio of dictyosporous to phragmosporous ascospores. On V8 99% of the ascospores were muriform. On MEA 60% of the ascospores observed in squash mounts were muriform, whereas 68% of the discharged ascospores were muriform. Discharged ascospores were slightly larger [(26)-29-(36) X (10)-13-(16) μm] than those measured in squash mounts. Both types of ascospores were capable of forming germ tubes (Fig. 16).

Colony appearance on both V8 and MEA was affected by exposure to light. When a portion of a petri plate was covered with black, opaque construction paper, pseudothecia that formed under the covered portion developed darker pigmentation than those in direct light, so that the colony appeared black instead of brown. After pseudothecium development, most of the outer area of the colony became covered with a thick mat of cottony, white mycelium that later turned dark gray. Occasionally pseudothecia formed on the surface of this mycelial mat. When freshly inoculated agar plates were grown in the dark, the resulting colonies had abundant aerial hyphae. When such plates were later placed in light, aerial hyphae were greatly reduced on the new growth and pseudothecium formation was abundant.

Light also affected the elongation of the ostiolar neck and ascospore discharge. When grown in deep culture dishes with side lighting, the apex of the ostiolar neck became bent toward the light source, and the ascospores were discharged onto the side of the culture dish rather than onto the lid. When half of a petri plate was covered with black paper, no forcible discharge of ascospores occurred in the covered portion of the plate, whereas good discharge occurred in the uncovered portion (Fig. 13). Later, however, ascospores were extruded in a compact gelatinous mass from the ostioles of those pseudothecia not exposed to direct light. No forcible ascospore discharge occurred when covered ascomata were subsequently exposed to light. Passive ascospore release could also be observed in older cultures that had been exposed to light, but it occurred only following a period of normal forcible discharge. In plates that were initially grown in darkness and later transferred to light, forcible ascospore discharge was abundant in the new growth, but lacking or greatly reduced in the center, forming an "O"-shaped pattern on the petri plate lid.

DISCUSSION

Although the pepper spot fungus was originally placed in *Pleospora* (Sechet, 1955) because of the muriform ascospores that become light brown after discharge, it clearly belongs in *Leptosphaerulina* on the basis of its morphological characteristics. Yen *et al.* (1956) recognized this fact when they independently described the same fungus as *Leptosphaerulina arachidicola*. Jackson and Bell (1968), in transferring *P. crassiasca* to *Leptosphaerulina*, stated that although the type specimen of *P. crassiasca* could not be located, the illustrations and description published by Sechet left no doubt that *P. crassiasca* belonged in *Leptosphaerulina* and that *L. arachidicola* was conspecific with it. Such a transfer is legitimate, as the illustrations and description provided by Sechet can serve as the type in the absence of a type specimen (Art. 7.3; Greuter, 1988). For comparison, a translation of Sechet's original description in Latin (Sechet, 1955) follows:
"Perithecia at first immersed, then erumpent, globose, yellow-brown, submembranaceous, short papillate, 50-120 μ diam.; asci broadly clavate, thick-walled, 8-spored, 45-75 X 25-45 μ; aparaphysate; spores oblong-obovate, 21-27 X 8- 12 μ, hyaline or subhyaline, transverse septa 3-5, longitudinal septa 0-2, constricted at middle septum, slightly constricted at other septa.

Living in leaves of *Arachis hypogaea*, Lake Alaotra, Madagascar."

Like Jackson and Bell (1968), our efforts to locate the type of *P. crassiasca* also were unsuccessful. Similar attempts to locate the type of *L. arachidicola* revealed (C. Y. Chien, personal communication) that there is no type material for this species either. Consequently, to supplement the original description of Sechet, it was decided to select an existing culture and designate dried herbarium material of this isolate as a neotype, since a culture cannot serve as a type (Art. 9.5; Greuter, 1988).

The Taiwan isolate was sent by K. T. Huang to E. S. Luttrell (Graham and Luttrell, 1961), who deposited it in the American Type Culture Collection (Jong and Gantt, 1987). Ideally, this isolate should serve as the neotype, but its unusual growth charactristics compared to the other isolates suggest that it has changed during storage, although in the original illustrations of this isolate it appears to form a continuous colony (Yen *et al.*, 1956). On oat and carrot agars a dense, cottony aerial mycelium covered the basal mycelium (Yen *et al.*, 1956); this is similar to the growth on MEA observed in the present study. The failure to discharge ascospores, however, is in direct contrast to the other isolates, although the presence of heavy aerial mycelium that shades the pseudothecia may affect this phenomenon. Graham and Luttrell (1961) reported that the Taiwan isolate sporulated well in darkness, although they did not comment specifically on spore discharge. Therefore, a Georgia isolate (P3480) has been selected to serve as the neotype for *L. crassiasca*. Isolate P3480 was selected because in ascospore size it conforms most closely to the original description, because of its characteristic behavior in culture, and its demonstrated ability to cause typical pepper spot symptoms on susceptible peanut cultivars. The continued virulence of this isolate after 24 years in culture is interesting.

In their discussion of the taxonomic status of *L. crassiasca*, Jackson and Bell (1968) listed *Pleospora arachicola* Huang as a synonym. This binomial was included in the handwritten undergraduate thesis prepared by Huang as part of his degree requirements, but it was neither validly published nor was it used subsequently (C. Y. Chien, personal communication). Booth and Pirozynski (1967) regarded *L. arachidicola* as a synonym of *L. trifolii* (Rostr.) Petr., but Irwin and Davis (1985) studied Australian isolates of these two species and concluded that they are distinct. Young *et al.* (1980) and Irwin and Davis (1985) applied the name *L. arachidicola* to the pepper spot fungus and made no mention of *L. crassiasca*.

Considerable variation has been reported in the literature for the sizes of morphological structures in *L. crassiasca* (Table 2). The greatest variation occurs in pseudothecia, which ranged in size from 50-248 μm in diameter. Variation also occurs in asci (30-101 X 25-84 μm) and ascospores (20-40 X 8-20 μm), but to a lesser degree. Of particular interest are the differences in the sizes of the pseudothecia, asci, and ascospores in the host and in culture. Our study agrees with that of Graham and Luttrell (1961), who reported that pseudothecia and asci from culture were considerably larger than those from host material. Ascospore size, however, showed much less variation. Although ascospores consistently form 3-5 transverse septa, there is considerable variation in the formation of longitudinal septa, which affects the ratio of phragmosporous to dictyosporous spores. The percentage of dictyospores tends to be higher in discharged ascospores as compared to those measured in squash mounts, suggesting that formation of longitudinal septa may occur late in ascospore maturation. Since both types of ascospores are capable of germination, however, the presence or absence of longitudinal septa appears to have little biological significance.

The effects of culture medium and light on the production of pseudothecia and ascospores shown here for our isolates confirm earlier reports. Suryanarayanan and Swamy (1977) reported that *L. crassiasca* (as *L. arachidicola*) failed to produce ascospores when grown in darkness on plain Czapek Agar (CA) or on CA covered by cellophane. When grown in light, ascospores formed only in plates containing cellophane when single-point inoculation was used, but when the inoculum was dispersed over the surface of the agar, ascospores formed in both plain CA and on CA plus cellophane. In subsequent studies they demonstrated (Suryanarayanan and Swamy, 1980, 1981) that the carbon and nitrogen sources in the medium affected sporulation and that the wavelength of light influences ascospore formation. These results were supported by Rao and Rao (1983), who found that ascospores formed in cultures grown in unfiltered light or under a yellow filter, but not when grown under blue, green or red cellophane filters.

Leptosphaerulina crassiasca has been reported throughout the peanut growing regions of the southeastern United States and other areas of the world. Besides Georgia (Luttrell and Boyle, 1960), it has been reported from Alabama (Hanlin, 1973), Florida (Farr *et al.*, 1989), North Carolina (Farr *et al.*, 1989), Virginia (Graham and Luttrell, 1961; Hanlin, 1973) and Texas (Pettit *et al.*, 1968) in the United States. Pepper spot and leaf scorch diseases also have been reported from Argentina (Frezzi, 1965), Australia (Irwin and Davis, 1985), India (Nayudu, 1963), Madagascar (Sechet, 1955), South Africa (Young *et al.*, 1980) and Taiwan (Yen *et al.*, 1956). The only reported hosts of *L. crassiasca* are species of *Arachis*. Graham and Luttrell (1961) reported *A. hypogaea* and *A. monticola* Krapov. & Rigoni as hosts, and Frezzi (1965) indicated that the rhizomatous species *A. burkartii* Handro, *A. glabrata* Benth., and *A. hagenbeckii* (Harms) Hoehne are also susceptible.

The presence of two distinct symptoms caused by the same fungus on the same host is unusual, especially since they usually do not occur together. The type of symptom expressed appears to be related to the genotype of the host cultivar. On cv. Tamnut used in these studies, the pepper spot symptom occurred far more frequently than that of leaf scorch. Excellent illustrations of the pepper spot and leaf scorch symptoms on peanut are provided by Jackson and Bell (1969).

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TABLE 1. Taxonomic characteristics of *Leptosphaerulina crassiasca* isolates examined in this study.

Source	Pseudotheci[a]	Asci	Ascospores	No. Septa	% Muriform
Florida (#9343) (Leaf)	112-164-220 high X 80-128-180 wide	64-77-100 X 32-37-46	[b]28-33-36 X 10-13-26	3-5	36
			[c]28-33-38 X 12-14-16	3-5	68
Georgia (P3480) (Peg)	90-135-180 high X 82-127-180 wide	58-71-84 X 30-42-52	[b]22-30-34 X 8-13-17	3-5	44
			[c]28-33-38 X 10-15-20	3-5	99
Georgia (P3975) (Leaf)	100-161-210 high X 80-127-184 wide	62-77-94 X 30-37-52	[b]21-31-37 X 9-13-16	3-5	60
			[c]26-32-36 X 11-14-16	3-5	68
Georgia (#9389) (Leaf)	140-173-204 high X 76-122-160 wide	62-72-88 X 28-36-42	[b]29-32-36 X 11-13-16	3-5	68
			[c]29-34-41 X 12-15-19	3-5	68
Taiwan (ATCC 13446) (Leaf)	100-142-180 high X 72-113-160 wide	40-52-62 X 27-33-40	[b]24-28-39 X 10-12-14	3-5	40
			[c]25-30-35 X 10-14-21	3-5	68

[a] Sizes represent averages of 25 measurements.
[b] Ascospores from pseudothecia in culture.
[c] Discharged ascospores from lid of petri plate.

TABLE 2. *Leptosphaerulina crassiasca* sizes[a] reported in the literature (μm)

Source	Pseudothecia	Asci	Ascospores	No. Septa	% Muriform
Sechet	50-95-120 diam	45-62-75	21-24-27		
(1955)		X 25-33-45	X 8-10-12	3-4	*
Yen *et al.*					
(1956) Host	73-91 high	56-72	25-33		
	X 66-80 wide	X 30-32	X 11-16	3-4	100
Culture[b]	24-248 diam	56-92	26-30-33		
		X 31-39	X 10-13-14	3-4	80
Graham & Luttrell					
(1961) Host	64-140 diam	53-78	23-30-40		
		X 28-42	X 11-13-17	3	64-84
V8 agar	90-216 diam	58-101	26-30-33		
		X 31-42	X 10-13-17	3-5	64-84
Nayudu					
(1963)	75-123 diam	40-69	25-28		
		X 25-37	X 9-12		*
Frezzi	70-130 diam	70-90	27-40	3-5	*
(1965)		X 35-50	X 8-18		
Jackson &					
Bell (1968)	60-120 diam	50-80	23-40	3-4	100
		X 25-45	X 11-17		
Irwin & Davis					
(1985)	NR	NR	25-34	3-5	76
			X 9-14		
Neotype					
(1990) Host	76-99-146 high	30-46-60	20-24-26		
	X 70-86-125 wide	X 12-27-40	X 4-8-10	3-5	
V8 agar	90-135-180 high	58-71-84	28-33-38		
	X 82-127-180 wide	X 30-42-52	X 10-15-20	3-5	99

[a] Sizes originally given as fractions have been rounded to full numbers.
[b] As reported by Luttrell and Boyle (1960).
*No percentage given, but some spores phragmosporous.
NR = Not reported

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ADDITIONS TO THE GENUS GYMNOPILUS (AGARICALES, CORTINARIACEAE) FROM MEXICO *

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SUMMARY

Tree new species of *Gymnopilus* from the State of Jalisco (Mexico) are described: *G. acystidiatus, G. nevadensis* and *G. subpurpuratus*. In addition *G. liquiritiae* (Pers. : Fr.) Karst. is recorded for the first time from Mexico. Including these four species there is a total of 19 species of *Gymnopilus* known from Mexico.

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INTRODUCTION

The genus *Gymnopilus* has been little studied in Mexico; prior to this paper only 15 species were known in contrast with the 78 world-wide species accepted by Singer (1986). Undoubtedly there are many additional species in Mexico yet to be studied.

The authors recently initiated the study of the genus *Gymnopilus* in Mexico (Guzmán-Dávalos & Guzmán, 1986). In the present paper three new species are described and *G. liquiritiae* (Pers. : Fr.) Karst. is recorded for the first time from Mexico. Collections of all species studied have been deposited in the Herbarium of the Instituto de Botánica of the Universidad de Guadalajara (IBUG). In addition collections of some species have been deposited in the herbaria at the Instituto de Ecología (XAL), at the Escuela Nacional de Ciencias Biológicas of the Instituto Politécnico Nacional (ENCB) and at the University of Michigan (MICH). Microscopic observations were made from material mounted in 5 % KOH and Melzer's reagent. The ornamentations of the spore walls are included in spore measures.

Gymnopilus liquiritiae **(Pers. : Fr.) Karst.,** ***Bidr. Finl. Nat. Folk 32*****: 400. 1879.**

Figs. 1-11

Pileus 25-40 mm broad, convex to plane, with a slight central depression, margin extremely uplifted with age, dry, glabrous, orange yellow to golden orange. Lamellae adnexed to sinuate, close, ventricose, wavy, mustard yellow with orange shades, margin granulate yellowish. Stipe 30-40 x 3-9 mm, equal to narrowed below, sometimes subbulbous at the base, fibrillose, whitish yellow at the base, yellowish brown toward the apex, solid, with white rhizomorphs, veil none. Context whitish to yellowish, odor fungic agreeable, slightly to rubber, taste bitter.

Spores (6.8-) 7.6-9.6 (-10.4) x 4.4-5.6 µm, ellipsoid, verruculose, without germ pore, yellowish golden brown, dextrinoid. Basidia 24-32 x 6-7.2 µm, tetraspored, some bi- or trisporic, clavate, some with central constriction, hyaline to grayish yellow, sterigmata 2.4-4.8 µm long. Pleurocystidia 17.6-25.6 x 5.2-7.2 µm, apex 3.6-5.2 µm in diam., ventricose, subcylindric or flask-shaped, subcapitate, grayish yellow, scattered and inconspicuous. Cheilocystida 20-32 x 4.8-8.8 µm, apex 4-6.4 µm in diam., flask-shaped, capitate or subcapitate, some with a long neck, some ventricose-clavate with subcapitate apex, hyaline, some with yellowish or yellowish brown content, scattered. Gill trama interwoven to subparallel. Pileus trama with interwoven hyphae, except at the junction between the lamellae and pileus where they are radially arranged. Cuticle with hyphae 4-15.2 µm broad, postrate, yellowish to yellowish brown, more o less incrusted. Pileocystidia absent. Caulocystidia 16.8-51.2 x 2-7.2 µm, apex 3.6-6 µm broad, cylindric-ventricose, not capitate, subcapitate found only at the stipe apex, occurring in tufts, hyaline to yellowish brown. Clamp connections present.

HABITAT. Cespitose on a dead *Pinus* trunk in *Pinus* with some *Quercus* forest.

MATERIAL STUDIED. MEXICO: STATE OF JALISCO, Municipality of Mazamitla, Monteverde, Guzmán-Dávalos 4132 (IBUG, XAL, ENCB, MICH). U.S.A.: Nuevo Mexico, Santa Fe Co., around Santa Fe, Barrows 618 (MICH).

OBSERVATIONS. This species is recognized by the color of the basidiocarp, glabrous pileus and tufted caulocystidia. According to Hesler (1969) and Moser (1983), this species has a yellow or light orange context, however in the Mexican specimens the context was whitish to yellowish. Furthermore, Hesler mentioned that this species has pileocystidia, however they were not observed in the material from Jalisco and, likewise, were not found in the material from U.S.A. that was determined by Hesler. Horak (1968) also described this species as lacking pileocystidia. *G. liquiritiae* has been cited from U.S.A., Europe and Japan by Imai (1938), Kühner and Romagnesi (1953), Hesler (1969), Imazeki and Hongo (1969), Moser (1983) and Smith-Weber and Smith (1985). This is the first record of its presence in Mexico.

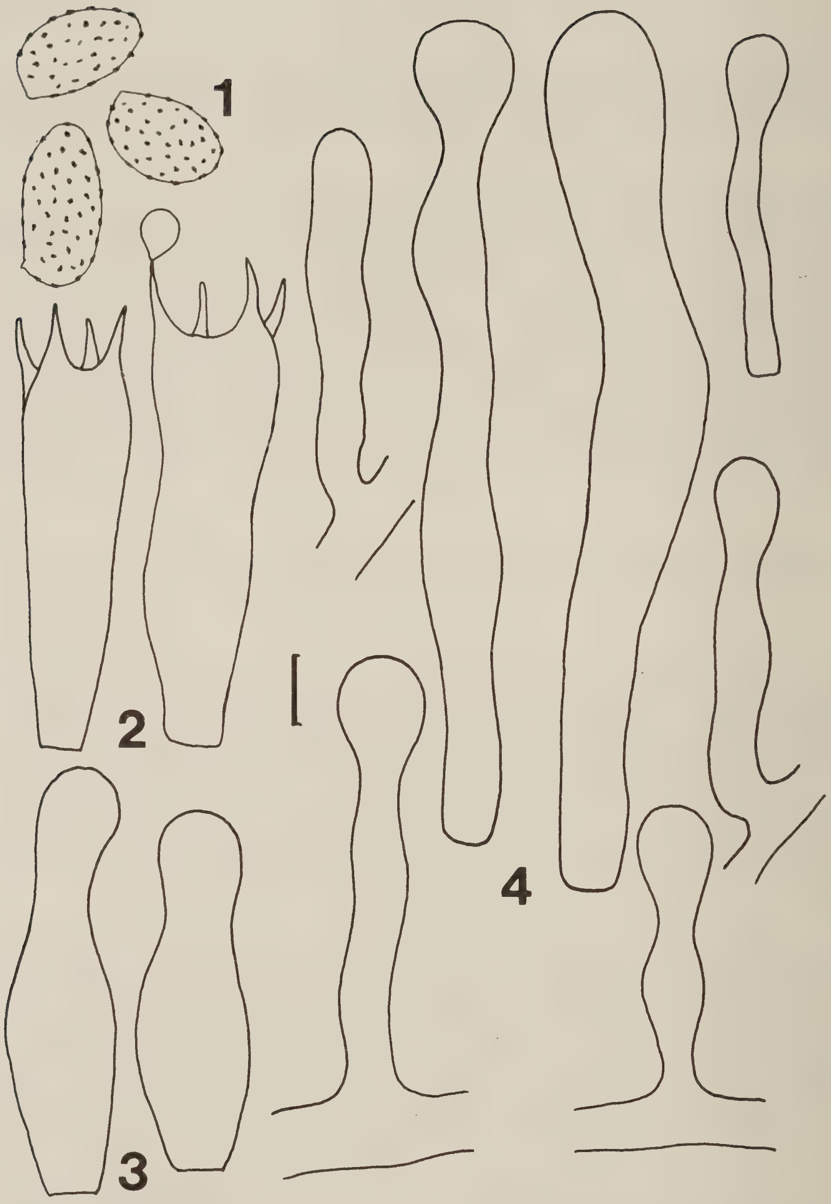
Gymnopilus acystidiatus **Guzmán-Dávalos & Guzmán, sp. nov.**

Figs. 12-14

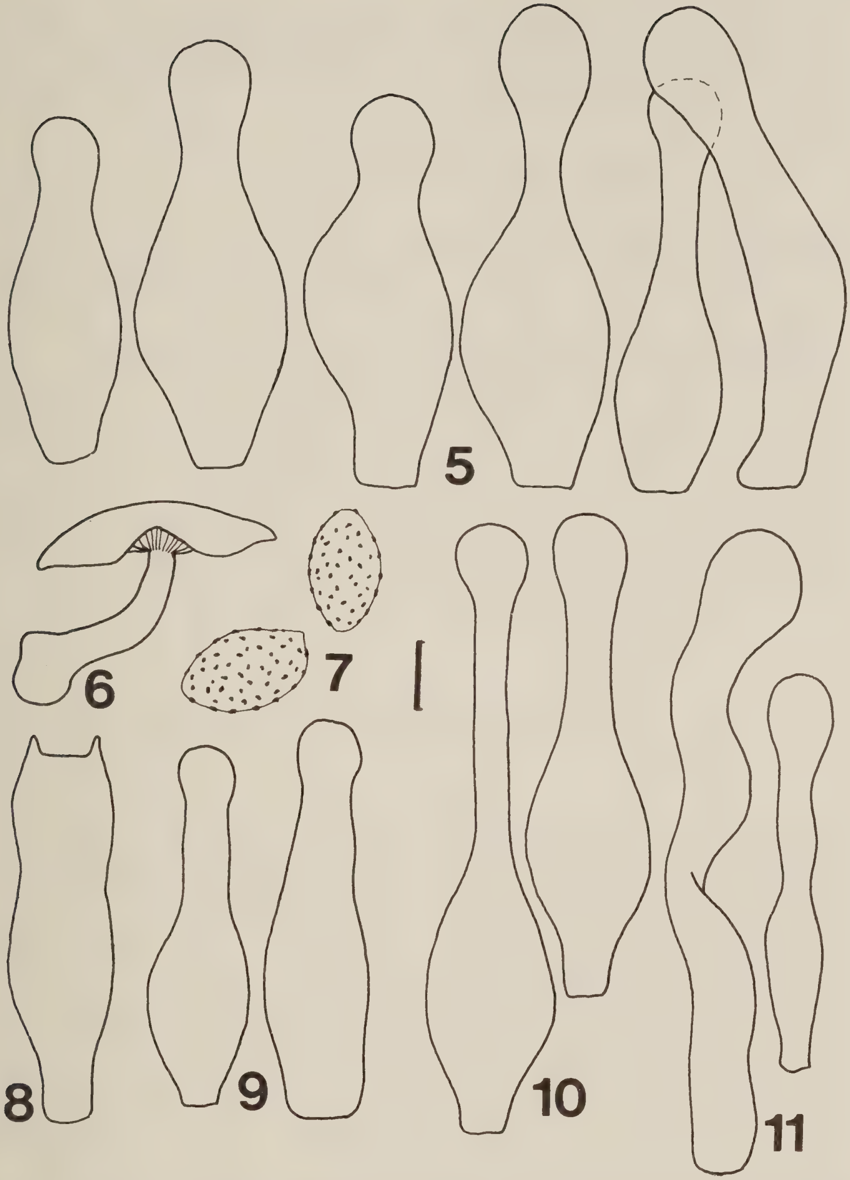
Pileus 17-26 mm latus, radivus aurantiacus brunneus, fibrillosus, marginis appendiculatus. Lamellae adnatus vel sinuatus, aurantiacus brunneus cum flavus umbrae. Stipes 38-48 x 3-6 mm, fibrillosus, aurantiacus brunneus clarus, cum evanescens veil. Contextum brunneus clarus cum aurantiacus umbrae. Sporae (7.2-) 8-11.2 (-12) x (4-) 4.8-6 (-6.8) µm, subellipsoide vel subfusiformis, subtiliter verrucosae, dextrinoidae. Pleurocystidia, cheilocystidia, pileocystidia et caulocystidia absentia. Fibuligerus. Terrestris in *Pinus-Quercus* Sylva, Jalisco, prope Mezquitic, Bajio Los Tules. Typus *Guzmán-Dávalos 3361* (IBUG).

Pileus 17-26 mm broad, campanulate mammillate, hygrophanous, fibrillose, grayish orange-brown, center dark redish brown, margin appendiculate, with whitish, fibrillose-cottony remnants of the partial veil. Lamellae adnate to sinuate, subdistant, ventricose, orange brown with mustard shades, margin entire. Stipe 38-48 x 3-6 mm, slightly tapered at the center, clavate subbulbousat base, silky fibrillose, light orange brown, base whitish, solid, with inconspicuous and evanescent, fibrillose remains of the partial veil. Context light brown with orange shades, odor fungal agreeable, taste not distinctive. KOH stains pileus reddish black.

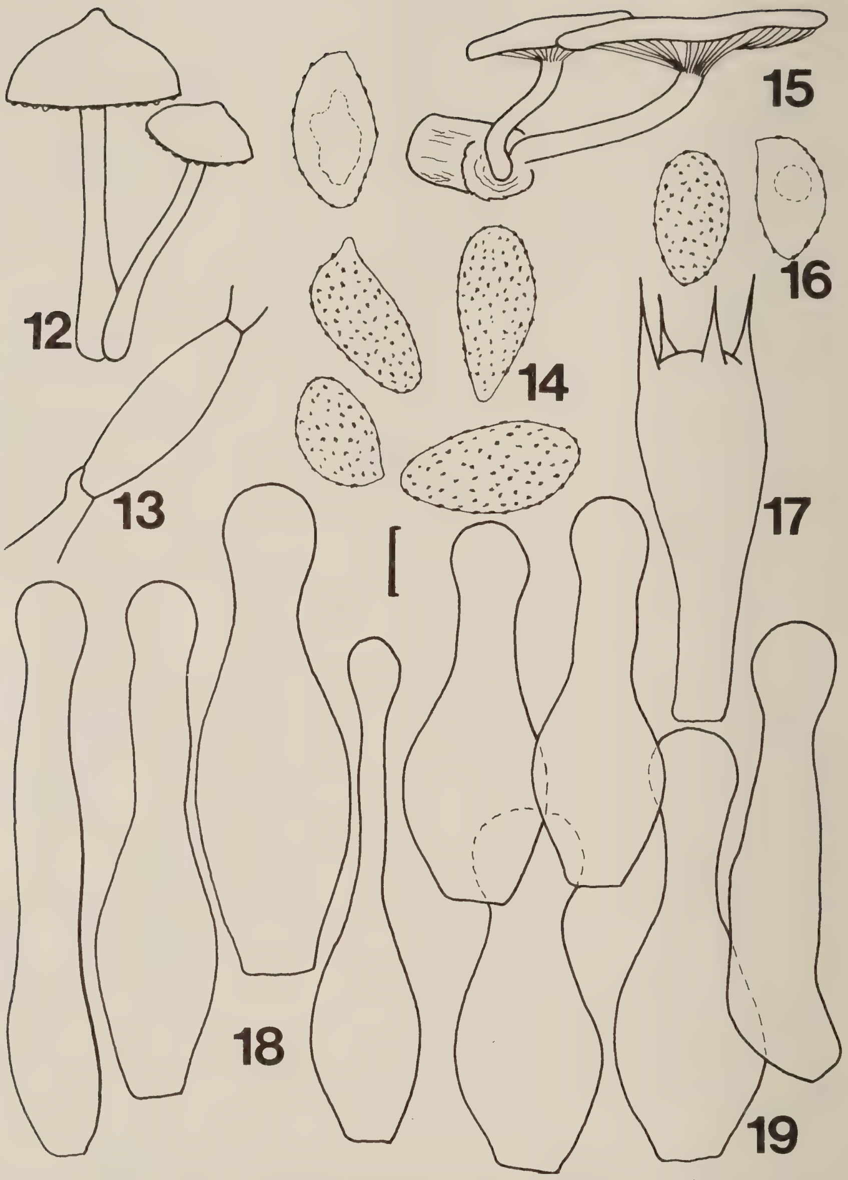
Spores (7.2-) 8-11.2 (-12) x (4-) 4.8-6 (-6.8) µm, amygdaliform to subfusiform, finelly verruculose, germ pore absent, light yellowish brown, dextrinoid. Basidia (25.6) 28-40 (-42.4) x (5.6-) 6.4-8.8 µm, tetraspored, clavate or subventricose with a central constriction, hyaline, with or without yellowish gray content. Pleurocystidia and cheilocystidia absent. Gill trama subparallel hyphae 10.4-28 µm



Figs. 1-4: *Gymnopilus liquiritiae*, 1: spores; 2: basidia; 3: pleurocystidia; 4: caulocystidia (*Guzmán-Dávalos 4132*) (scale bar = 4 µm).



Figs. 5-11: *Gymnopilus liquiritiae*, cheilocystidia (*Guzmán-Davalos 4132*); 6: basidiocarp; 7: spores; 8: basidium; 9: pleurocystidia; 10: cheilocystidia; 11: caulocystidia (Barrows 618) (scale bar: 5=4 µm; 6 = 1 cm; 7-11 = 5 µm).



Figs. 12-19.- 12-14: *Gymnopilus acystidiatus*, 12: basidiocarps; 13: gill trama clamped; 14: spores (Holotype). 15-19: *G. nevadensis*, 15: basidiocarps, 16: spores; 17: basidium; 18: pleurocystidia; 19: cheilocystidia (Holotype) (scale bar: 12 & 15 = 1 cm; 13-14 & 16-10 = 4 µm).

broad, short cells with tapered ends, thin wall, hyaline to yellowish, with clamp connections. Pileus trama with radially arranged hyphae 12-34.4 µm broad, with short cells, yellowish. Cuticle with postrate hyphae, yellowish brown to light orange brown, with incrusted walls. Pileocystidia and caulocystidia absent. Clamp connections present in all the hyphae.

HABITAT. Cespitose, on soil in *Pinus-Quercus* forest.

MATERIAL STUDIED. STATE OF JALISCO, Municipality of Mezquitic, road Bolaños-Tenzonpa, 4 km before Bajío Los Tules, *Guzmán-Dávalos 3361* (Holotype, IBUG; Isotypes, XAL, MICH).

OBSERVATIONS. The mammilate pileus with appendiculate margin, the absence of all type of cystidia and the terrestial habitat are distinguishing characteristics of this species. It is similar to *Gymnopilus rufobrunneus* Hesler because of similar carpophore color, terrestial habital and the absence of pleurocystidia and cheilocystidia (Hesler, 1969). However, an examination of the holotype revealed that the spores have a germ pore, which suggests that it is not a *Gymnopilus* and best belongs to the genus *Descolea*. *Gymnopilus acystidiatus* is distinguished from *G. subrufobrunneus* Guzmán-Dávalos & Guzmán because of its convex pileus, short but robust carpophore, with radish odor, the vinaceous brown staining stipe, the interwoven pileus trama and the presence of caulocystidia (Guzmán-Dávalos and Guzmán, 1986).

Gymnopilus nevadensis **Guzmán-Dávalos & Guzmán, sp. nov.**

Figs. 15-20

Pileus 20-40 mm latus, fibrillosus, flavidus brunneus vel flavidus aurantiacus cum flavus umbrae. Lamellae brevis decurrens, griseolus aurantiacus brunneolis. Stipes 20-30 x 2-3.5 mm, fibrillosus, albidus with aurantiacus brunneus umbrae. Contextum flavidus. Sporae 6.8-8.8 (-9.6) x 4-4.8 (-5.6) µm, ellipsoidae, subtiliter verrucose, dextrinoidae. Pleurocystidia 27.2-33.6 x 5.6-8.8 µm, ventricosus cylindraceus vel ampullaceus, hyalinae vel flavidus. Cheilocystidia 22.4-26.4 x (4.8-) 8-9.6 µm, ampullaceus, rarae ventricosus cylindridaceus, capitata vel subcapita, hyalinae vel flavidus vel brunneus. Pileocystidia absentiae. Caulocystidia (12-) 25.6-40 x 3.2-6.4 µm, ventricosus cylandraceus, subcapitata, hyalinae vel flavidus brunneus. Fibuligerus. Ligniciola ad *Pinus-Quercus* sylvae, Jalisco, prope Nevado de Colima, El Floripondio. Typus *Guzmán-Dávalos 3469* (IBUG).

Pileus 20-40 mm broad, convex to plane, glabrous or slightly fibrillose, dry, yellowish brown to yellowish orange with mustard shades, margin entire non striate. Lammellae short-decurrent, close, narrrow, grayish orange brown. Stipe 20-30 x 2-3.5 mm, equal, fibrillose, whitish, staining to dirty orange brown. Partial veil absent. Context yellowish, odor somewhat fungical. KOH staining pileus and stipe reddish-black.

Spores 6.8-8.8 (-9.6) x 4-4.8 (-5.6) µm, ellipsoid, finelly verruculose, germ pore absent, yellowish brown, dextrinoid. Basidia 22.4-29.6 x 5.6-7.2 µm, tetrasporic, clavate or subvesiculose, some with central constriction, hyaline, sterigmata 4-4.8 µm long. Pleurocystidia 27.2-33.6 x 5.6-8.8 µm, apex (2.8) 3.2-5.6 (-6.4) µm in diam., cylindric-ventricose or flask-shaped, commonly with a long neck, subcapitate, hyaline to yellowish, conspicuous but scattered. Cheilocystidia 22.4-26.4 x (4.8-) 8-9.6 µm, apex 4.8-6.4 µm in diam., flask-shaped, few cylindric-ventricose, capitate to subcapitate, hyaline, yellowish or yellowish brown. Gill trama subparallel. Pileus trama radial. Cuticle with postrate hyphae 3.6-11.2 µm broad, hyaline, yellowish or light yellowish brown, with incrusted walls. Pileocystidia absent. Caulocystidia (12-) 25.6-40 x 3.2-6.4 µm, apex 3.6-6.4 µm broad, cylindric-ventricose, subcapitate, hyaline, yellowish, grayish yellow or yellowish brown, found only at the stipe apex in scatteted tufts. Clamp conections present.

HABITAT. Cespitose, on an unidentified dead branch, in *Pinus-Quercus* forest.

MATERIAL STUDIED. STATE OF JALISCO, Municipality of Ciudad Guzmán, Nevado de Colima foothills, El Floripondio, *Guzmán-Dávalos 3469* (Holotype, IBUG; Isotypes, XAL, MICH).

OBSERVATIONS. This species is distinguished by its short-decurrent lamellae and glabrous pileus. Microscopically it has pleurocystidia that are larger than the cheilocystidia. This uncommun characteristic in the genus, has only been observed in *G. pleurocystidiatus* Guzmán-Dávalos & Guzmán, which differs from *G. nevadensis* by having a smaller carpophore with a short stipe, a fibrillose veil, pleurocystidia 19.2-24.8 x 4.8-6.4 µm, cheilocystidia 13.6-21.6 x 3.2-7.2 µm and caulocystidia 37.6-72.8 x 4-8 µm (Guzmán-Dávalos and Guzmán, 1986). *G. nevadensis* is also close to *G. liquiritiae* (Pers. : Fr.) Karst., but it has adnate to sinuate lamellae and small inconspicuous pleurocystidia. Another related species is *G. mitis* Hesler, but it has a veil, pleurocystidia 17-28 x 5-8 µm, cheilocystidia 23-30 x 6-8 µm, an interwoven pileus trama and pileocystidia (Hesler, 1969).

The name of the species refers to the Nevado de Colima, where the species was collected.

Gymnopilus subpurpuratus **Guzmán-Dávalos & Guzmán, sp. nov.**

Figs. 21-28

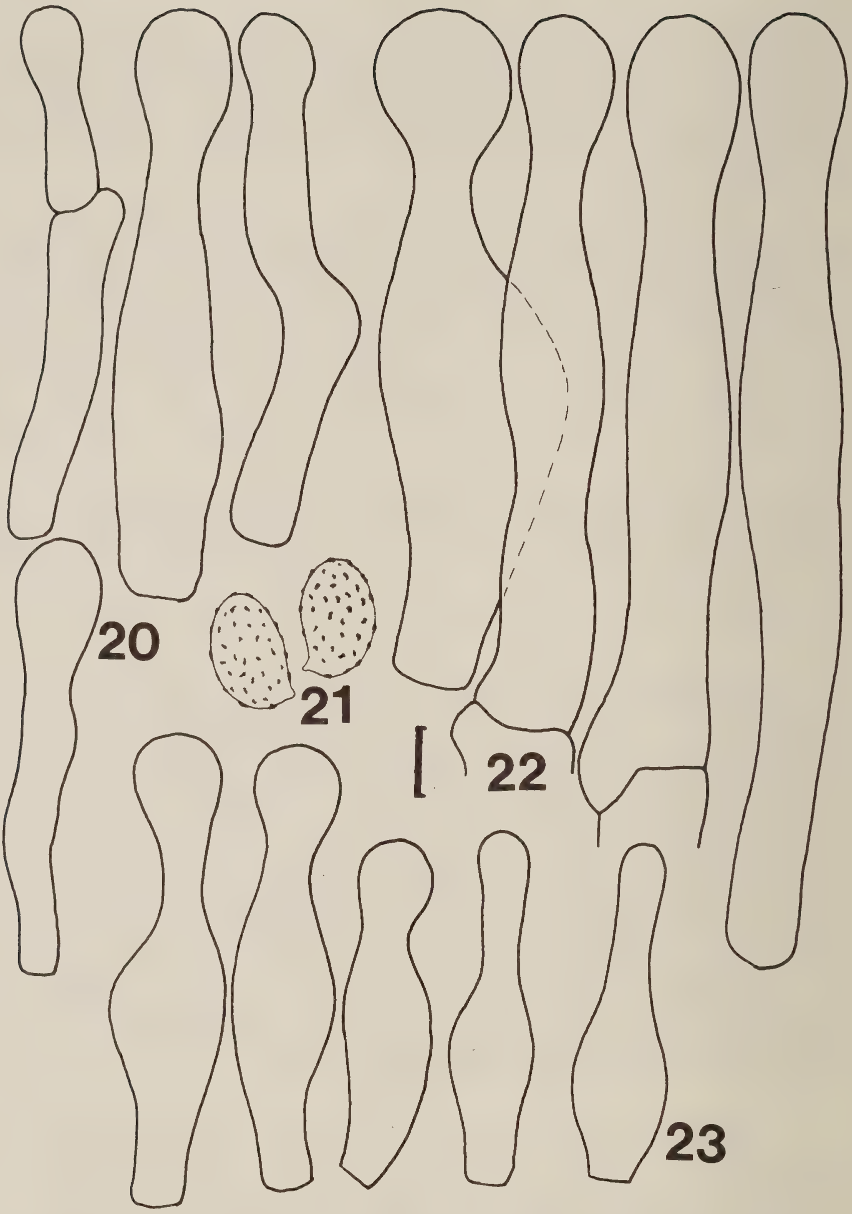
Pileus 18-53 mm latus, squarrosus vel squamulosus appressus, aurantiacus flavus cum rubricosus brunneus vel purpureus squamae; caerulescente. Lamellae adnatus vel subdecurrens, flavus vel aurantiacus flavidus vel ferrugineus. Stipe 10-30 x 2-6 (-9) mm, albidus griseolus, cum maculo rubricosus. Velum arachnoideus, brunneus ferrugineus. Contextum albidus vel subflavidus. Sporae 6-8 x 4-4.8 µm, ellipsoidae, verrucosae, dextrinoidae. Pleurocystidia absentiae. Cheilocystidia 16.8-28 x 5.6-7.6 µm, ampullaceus, subcapitata vel capitata, griseolus flavidus. Pileocystidia absentiae. Caulocystidia 24-68 x 3.6-12 µm, ventricose cylindraceus, subcapitata vel capita, inusitatus ampullaceus vel clavatus, hyalinae vel flavidus griseolus. Fibuligerus. Lignicola in hortus, Jalisco, prope Nextipac, Instituto de Botánica. Typus *Guzmán-Dávalos 4773* (IBUG).

Pileus 18-53 mm broad, convex, plano-convex to plane, finally uplifted, dry, squarrose to appresed-squamulose, especially on the disc, small scales or fibrilles reddish brown to purple, back-ground color to orange yellowish, light reddish yellow or purple-yellow, scales sometimes evanescent with age, margin entire, with ferruginous-brownarachnoid remains of the partial veil; pileus surface staining green when bruising. Lamellae adnate with or without a decurrent tooth to subdecurrent, close, broad to subventricose, yelow to ferruginous orange or ferruginous brown when mature, edge entire to subfarinaceous, yellowish. Stipe 10-30 x 2-6 (-9) mm, central to excentric, equal, slightly broader at the base, folded like an "L" or suberect, fibrillose, grayish white with purple or reddish stains, solid to hollow. Veil arachnoid, ferruginous brown, forming an inconspicuous apical fibrillose annulus. Context whitish to yellow-whitish. Odor farinaceous and sweet, taste bitter. KOH staining pileus with olivaceous-green spots with purple margins; on the lamellae yellowish brown; on the stipe purple brown to almost black and on the context greenish yellow.

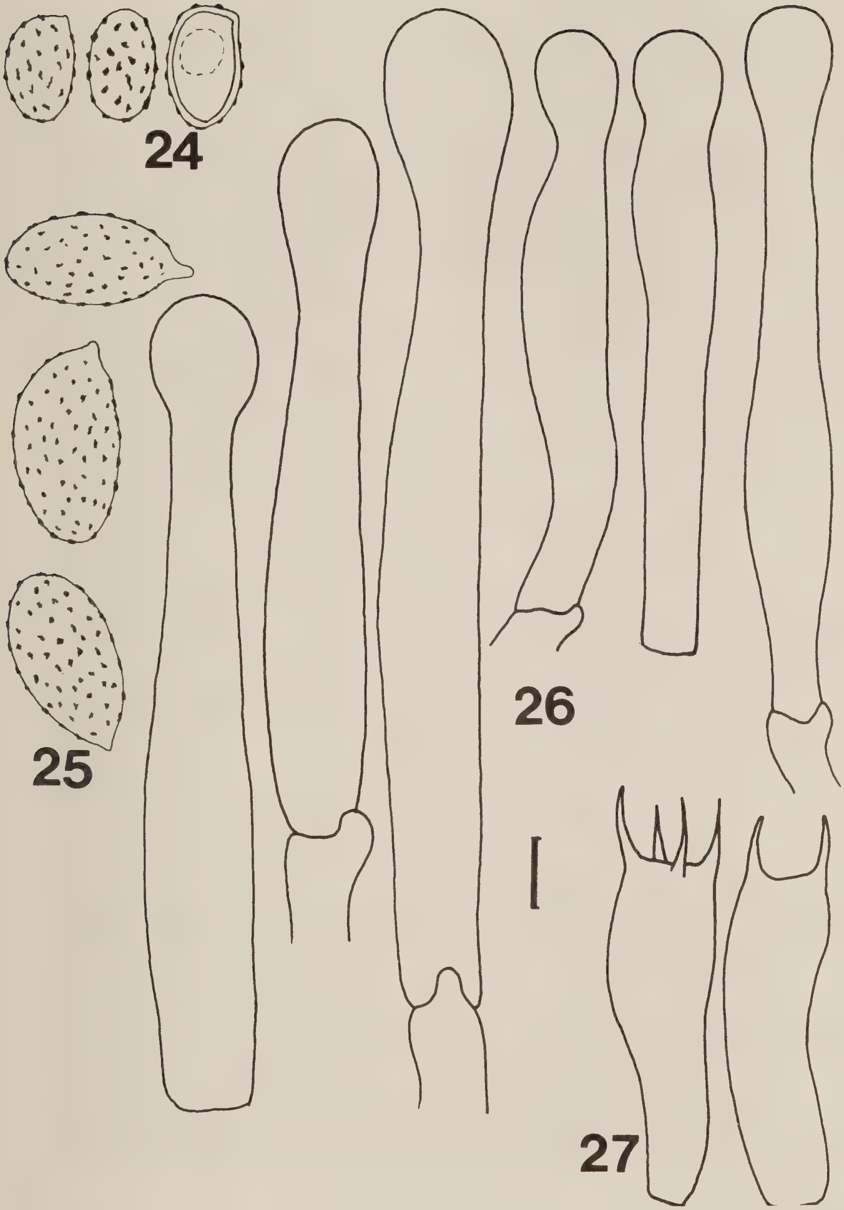
Spores ferruginous brown in mass, 6-8 x 4-4.8 µm, ellipsoid, verruculose, germ pore absent, yellowish-orange-brown, with refringent content, dextrinoid. Basidia 19.2-24 x 5.6-7.2 µm, bi-or tetrasporic, clavate or subcylindric, some with central constriction, with granulose, yellowish gray content, sterigmata 1.6-4 µm long. Pleurocystidia absent. Cheilocystidia 16.8-28 x 5.6-7.6 µm, apex 3.2-6.4 µm in diam., flask-shaped, subcapitate or capitate, some with a long neck, with granulose, yellowish gray contents. Gill trama subparallel. Pileus trama interwoven, hyphae 4-24 µm broad, septate, with thin wall. Cuticle with hyphae 4-14.4 µm broad, postrate, yellowish, except for fibrills, wich are yellowish-orange-brown, some with distinct incrustations. Pileocystidia absent. Caulocystidia 24-68 x 3.6-12 µm, apex 4.8-8 µm broad, cylindric, ventricose-cylindric subcapitate or capitate, some flask shaped or clavate, hyaline or rarely yellowish gray or yellowish-orange, present only in the stipe apex, in tufts, very common. Clamp connections present. Laticiferous hyphae present. A yellowish pigment is disolved when mounted in KOH.

HABITAT. Gregarious to cespitose in a garden on pine-wood of unknown origen.

MATERIAL STUDIED. STATE OF JALISCO, Municipality of Zapopan, Nextipac, Guadalajara University, Institute of Botany, *Guzmán-Dávalos 4773* (Holotype, IBUG; Isotypes, XAL, ENCB, MICH), *3914* (IBUG), *4202* (IBUG, XAL), *4775* (OBUG), *4855* (IBUG< ENBC), *5109,* (IBUG, MICH)



Figs. 20-23.- 20: *Gymnopilus nevadensis*, caulocystidia (Holotype). 21-23: *G. subpurpuratus*, 21: spores; 22: caulocystidia; 23: cheilocystidia (Holotype) (scale bar=4 µm).



Figs. 24-27: *Gymnopilus subpurpuratus*, 24: normal spores; 25: anormal spores; 26: caulocystidia; 27: basidia (*Guzmán-Dávalos 4202*) (scale bar = 4 µm).

OBSERVATIONS. *G. subpurpuratus* is characterized by the small fibrillose-scales on the disc, the greenish stains and the veil forming an anular zone. The green staining suggest a relationship with *G. aeruginosus* (Peck) Sing., however, this latter species is greenish with yellow and reddish spots, more scaly, has pleurocystidia and has a different type of caulocystidia (Hesler, 1969; Imazeki & Hongo, 1971 and Valenzuela *et al.*, 1981). It is also close to *G. peliolepis* (Speg.) Sing., but it has reddish-purple scales, does not stain green and the cheilocystidia are fusoid or ampullaceous, non-capitate. It also is related to *G. luteofolius* (Peck) Sing. but is distinguished by the reddish to vinacous context, discoloring to yellowish (Singer, 1951-A & 1951-B; Hesler, 1969). *G. luteoviridis* Thiers stains green, but has pleurocystidia and no caulocystidia (Thiers, 1959). Macroscopically, it resembles to *G. purpuratus* (Cooke et Mass.) Sing., but that species has larger spores (Singer, 1969; Lazo, 1984). The material Guzmán-Dávalos 4202 also has spores 8-12 x 4-8-6.4 µm, that are ellipsoid-elongate in addition to the typical spores.

ACKNOWLEDGEMENTS.

The authors express their thanks to Universidad de Guadalajara and to Instituto de Ecología for their support to this work. Guzmán-Dávalos thanks Dr. R.L. Shaffer of the University of Michigan Herbarium who kindly permited to review materials in that herbarium. Their colleagues L. Montoya and V. Bandala from the Instituto de Ecología at Xalapa kindly revised this paper. Bandala also prepared the final version of drawings Dr. H.D. Thiers of the San Francisco State University kindly revised this paper.

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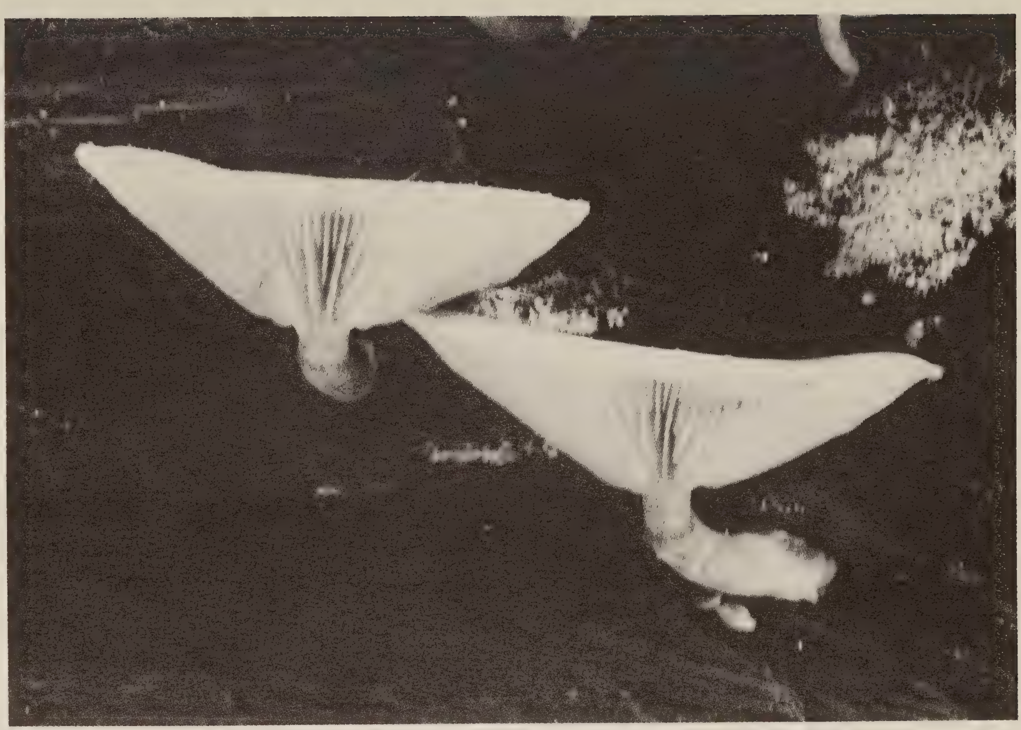

Fig. 28. *Gymnopilus subpurpuratus* in its habitat (*Guzmán-Dávalos 4202*).

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LECANORA SECT. PETRASTERION (LICHENIZED ASCOMYCOTINA) IN NORTH AMERICA: NOTES ON THE L. NOVOMEXICANA COMPLEX (SUBSECT. PSEUDOCORTICATAE)

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ABSTRACT. The *Lecanora novomexicana* complex of lobate to areolate-squamulose taxa in sect. *Petrasterion* subsect. *Pseudocorticatae* Poelt is well represented in semi-arid temperate to alpine areas over much of western North America, and is characterized by usnic acid and fatty acids as constant major substances, and yellowish pruinose to blue-black discs. *Parmularia novomexicana* B. de Lesd. and *L. thomsonii* Magnusson are treated in this article as synonyms of *L. novomexicana* Magnusson. At least some of the considerable variability in *L. novomexicana sensu lato* correlates with environmental factors; psoromic acid is often absent at high elevations and latitudes and is mostly replaced by lecanoric acid at low elevations in the Southwest. *Lecanora nigromarginata* Magnusson, although frequently confused with *Rhizoplaca melanophthalma* (DC.) Leuck. & Poelt, is provisionally retained as a separate taxon. *Lecanora novomexicana* Magnusson is unrelated to its later homonym, *L. novomexicana* B. de Lesd.

INTRODUCTION

As treated here, *Lecanora novomexicana* Magnusson *sensu lato* (including *L. thomsonii* Magnusson) together with *L. nigromarginata* Magnusson constitute an extremely variable and problematic species complex, and was treated only briefly by Poelt (1958) and Weber (1975). The purposes of the present article are to resolve the nomenclatural problems surrounding the name "*Lecanora novomexicana*", and to give some preliminary comments on the taxonomy of the complex. Full descriptions of the taxa and their variability, which requires analyses of thousands of specimens, are not presented here. Throughout this paper, unless specified otherwise, the name *Lecanora novomexicana* refers to the species described by Magnusson (1932), in a broad sense.

METHODS AND TERMINOLOGY

Unless noted otherwise, the methods and terminology used in this paper are as described by Ryan (1989a,b). Colors (followed by numbers in parentheses), as viewed through a dissecting microscope with fiber optic lighting, refer to the system of Kelly (1965). Herbarium acronyms follow those in Holmgren and Keuken (1974).

Chemical analyses were made by the standard thin-layer chromatographic (TLC) method of Culberson (1972), modified as described by Ryan (1989a). Fatty acids were identified with the help of C. Leuckert and J. Elix. Although only about three hundred specimens of *L. novomexicana* have been tested in this study so far, over a thousand were spot tested for psoromic acid (Pd+ yellow) and lecanoric acid (C+ red). The TLC data have agreed very well with the spot tests.

RESULTS AND DISCUSSION

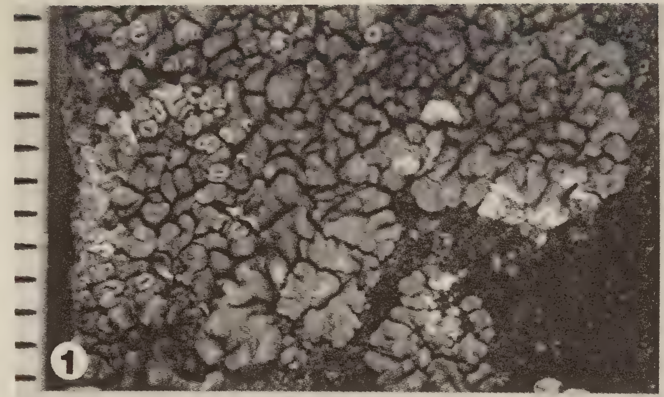
The members of the *Lecanora novomexicana* complex (Figs. 1-4) are distinguished from other members of sect. *Petrasterion* subsect. *Pseudocorticatae* Poelt (type species *L. nigromarginata*), by: 1) lobate to areolate-squamulose thalli; 2) yellowish-pruinose to epruinose blue-black discs; 3) presence of usnic acid, fatty acids and often psoromic or lecanoric acids (or both) as major substances; and 4) occurrence in semi-arid temperate to alpine areas over much of western North America. The relationships of members of the *L. novomexicana* complex to other species of sect. *Petrasterion* *sensu* *lato* are discussed in separate articles (Ryan, 1989c, and Ryan & Nash, in preparation).

Notes on Taxa in the *Lecanora novomexicana* Complex

1. ***Lecanora (Placodium) novomexicana*** **Magnusson,**

Ann. Crypt. Exot. 5(1): 26 (1932) not *L. novomexicana* B. de Lesd., Rev. Bryol. et Lichénol., n.s., 12: 56 (1942). **TYPE:** U. S. A. New Mexico. San Miguel Co.: near Las Vegas, 1927, *Brouard, s.n.*, **Holotype** (UPS!) (Fig. 1).---[*Lecanora (Parmularia) muralis* f. *novomexicana* B. de Lesd. in Magnusson, Ann. Crypt. Exot. 5(1): 26 (1932), as synonym].

Figures 1-4. *Lecanora novomexicana* Magnusson *sensu* *lato* and *L. nigromarginata* Magnusson. Scale = mm. -1. Holotype of *Lecanora novomexicana* Magnusson (*Brouard, s.n.*, UPS!).-2. Lectotype of *Parmularia novomexicana* B. de Lesd. (*Brouard, s.n.*, UPS). -3. Holotype of *Lecanora thomsonii* Magnusson (*Thomson 2159*, UPS). -4. *Lecanora nigromarginata* Magnusson: holotype (*Grant, s.n.*, UPS).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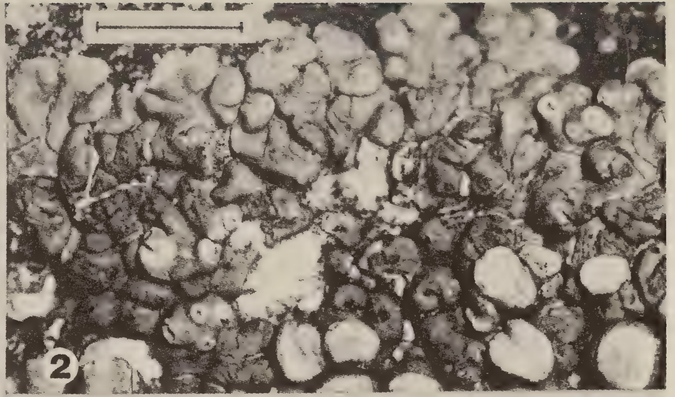
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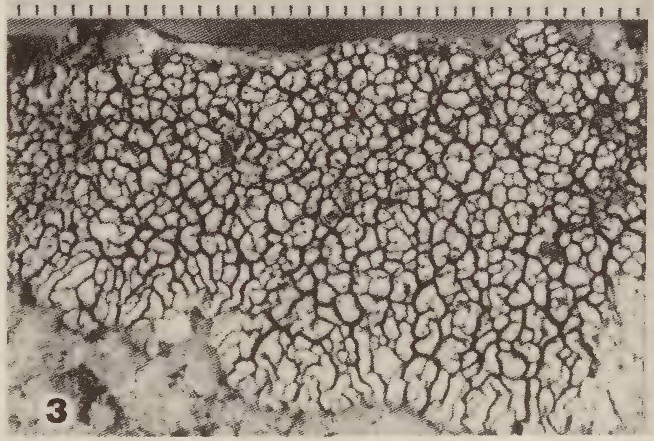
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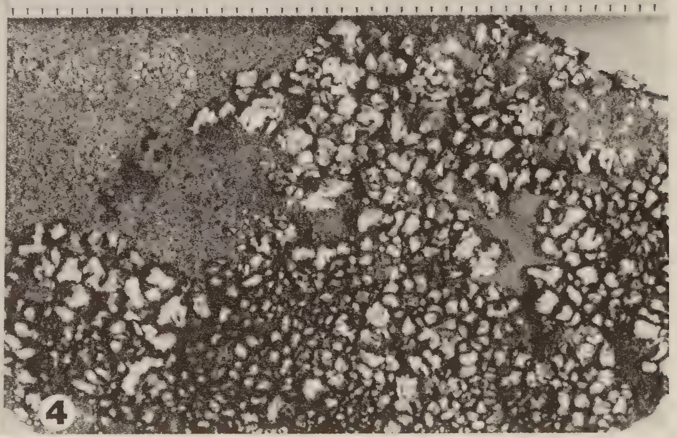
4

Parmularia novomexicana B. de Lesd., Ann. Crypt. Exot. 5(2): 118 (1932). **TYPE (from the protologue):** U. S. A. New Mexico. San Miguel Co.: "Gallinas Cañon sud, Thunderbird Ranch, Kearney's gap, Storries project; common aux environs de Las Vegas, sur roches siliceuses", leg. Brouard. **Lectotype (selected here):** Environs de Las Vegas: Cañon sud, 1870 m., 1930, Brouard, s.n. (UPS!) (Fig. 2).

Lecanora novomexicana Magnusson f. nigra (B. de Lesd.) Zahlbr., Cat. Lich. Univ. 10: 490 (1940).---Parmularia novomexicana B. de Lesd. f. nigra B. de Lesd., Ann. Crypt. Exot. 5(2): 118 (1932). **TYPE (from the protologue):** U. S. A. New Mexico. San Miguel Co.: "Gallinas cañon sud.", near Las Vegas, undated, leg. Brouard. Not seen; apparently destroyed during World War II.

Parmularia novomexicana B. de Lesd. f. reagens B. de Lesd., Rev. Bryol. et Lichénol., n.s., 12: 56 (1942). **TYPE (from the protologue):** U. S. A. New Mexico. Santa Fe Co.: "Bajada Nueva, lavicole", 30 km S of Santa-Fe, 1850 m, undated, leg. Brouard. Not seen; apparently destroyed during World War II.

Lecanora (Placodium) Thomsonii Magnusson, Acta Horti Gotoburg. 29(2): 47, fig. 9 (1952). (Fig. 3 in present article). **TYPE:** U. S. A. Wyoming. Johnson Co.: Big Horn Mts., Powder River Pass, at 9666 ft [2900 m], [Aug. 16] 1940, Thomson 2159, **Holotype** (including photo and notes used by Magnusson in original description) (UPS!).

In a later fascicle of the same volume of the journal in which Magnusson (1932) published Lecanora novomexicana Magnusson, Bouly de Lesdain (1932) published a similar but much shorter description of Parmularia novomexicana B. de Lesd. as a new species. The latter name was also based on specimens collected by Brouard from the vicinity of Las Vegas, New Mexico, presumably including the specimen sent to Magnusson as "Parmularia muralis f. novomexicana" (= holotype of L. novomexicana Magnusson). Because Magnusson's description was published slightly earlier, L. novomexicana Magnusson has priority, as was concluded by Zahlbruckner (1940), who listed "Lecanora novomexicana H. Magn." as the accepted name and gave as synonyms "Parmularia muralis f. novomexicana B. de Lesd. apud H. Magn." and "Parmularia novomexicana B. de Lesd.".

However, in the years since 1932, the name Lecanora novomexicana has been a source of nomenclatural confusion. The checklist of Egan (1987) listed, as "accepted" names, both "L. novomexicana Magnusson", and "L. novomexicana (B. de Lesd.) Zahlbr." (the latter combination was never actually made, except for f. nigra). In the literature, as well as on specimens in various herbaria, one finds a variety of different (often unpublished and incorrect) combinations of epithets and author names for material of more-or-less typical L. novomexicana Magnusson, including "L. novomexicana B. de Lesd. ex Magnusson" (Weber, 1981), and "Lecanora novomexicana (B. de Lesd.) B. de Lesd. non H. Magn." (many specimens at ASU).

The name Parmularia novomexicana B. de Lesd. was cited by Poelt (1958) as "Parmularia novomexicana (Magn.) B. de Lesd." and by Wetmore (1967) as "Parmularia novomexicana (B. de Lesd. ex Magn.) B. de Lesd.". Both Poelt and Wetmore cited "Ann. Crypt. Exot. 5(2): 118. 1932" as the source of the combination, which is incorrect, since Bouly de Lesdain never mentioned Magnusson's L. novomexicana in any of his articles.

Magnusson's holotype of L. novomexicana and the other specimens of the species collected by Brouard and seen by Bouly de Lesdain (including the lectotype of P. novomexicana) do not differ significantly, including in their chemistry (all have usnic and psoromic acids and the pertusaric-constipatic fatty acid complex). All of these Brouard specimens from near Las Vegas are quite representative of the morphotype common at low to moderate elevations in semi-arid, pinyon-juniper or pine woods from Arizona and New Mexico to Colorado and Utah. All have clearly radiating, rather thin and flat lobes, and pale, reddish to bluish apothecia covered by more-or-less dense yellowish pruina and the thallus color has changed with time from its normal grayish yellowish green (105), to light olive brown (84). Thus, it is clear that the same taxon was described twice, with P. novomexicana B. de Lesd. based partly on the same material as L. novomexicana Magnusson.

Bouly de Lesdain did not cite specific specimens for P. novomexicana, but listed several localities in the vicinity of Las Vegas, New Mexico, where Brouard had collected the species. Although the specimen at UPS contains no notes or other indication that it is a new species, it was chosen as the lectotype because (unlike other possible syntypes seen) it is labelled on the outside "HERB. BOULY DE LESDAIN", and (in Bouly de Lesdain's writing) "Parmularia novomexicana B. de Lesd.", with other data corresponding to one of the collections cited in Bouly de Lesdain's protologue.

Bouly de Lesdain's descriptions of P. novomexicana f. nigra ("Apothecia pruina caesio-nigra dense suffusa") and P. novomexicana f. reagens ("Thallus K+ dilute lutescit.") are too meager to permit an evaluation of the status of these taxa in the absence of type specimens.

Variability Within Lecanora novomexicana sensu lato.

The color and form of the thallus and apothecia of L. novomexicana sensu lato are extremely variable, even in specimens from the same locality. This is demonstrated in many collections, such as Nash 7813 (MIN), in which the thallus on one rock is quite usual for the species (lobes grayish tinged, thin and more-or-less flattened) while the specimen on another rock appears closer to "L. thomsonii" (lobes yellow, thick and very convex). The apothecia often vary greatly in color on the same thallus, as in other species with pruinose discs.

The medullary chemistry of *L. novomexicana* *sensu* *lato* is also variable. Although only about three hundred samples of *L. novomexicana* have been chromatographed in this study so far, over a thousand were spot tested for psoromic acid (Pd+ yellow) and lecanoric acid (C+ red). Psoromic acid occurs in many specimens throughout most of the considerable geographical and ecological range of the taxon (from southwestern semi-desert areas to alpine areas of the Northwest). However, specimens from boreal or alpine localities often contain only fatty acids in the medulla, and populations from low elevations in the southwestern states often contain lecanoric acid instead of psoromic acid; a few southwestern populations contain both psoromic and lecanoric acids (sometimes in the same thallus). Preliminary analyses suggest that this chemical variation (and perhaps also the amount of usnic acid in the cortex) may be correlated to some extent with morphological differences, including cortical thickness. However, much further study is necessary before the taxonomic status of the chemical and morphological variants in *L. novomexicana* *sensu* *lato* (including "*L. thomsonii*") can be properly evaluated.

The holotype of *L. thomsonii* differs from the type of *L. novomexicana* in a number of ways, especially in that *L. thomsonii* has lobes that are more convex and purely greenish yellow (104-105) with black edges, and apothecial discs that are mostly bluish black and non-pruinose. After we examined thousands of specimens from various locations along altitudinal and latitudinal gradients (including different microhabitats at the exact type locality of *L. thomsonii*), we could find no sharp, consistent distinctions between *L. novomexicana* and *L. thomsonii*. Preliminary evidence shows that the characteristics used to define *L. thomsonii* show a strong positive correlation with increased altitude and exposure, which suggests that *L. thomsonii* is probably an environmental modification, or at best an infraspecific taxon, of *L. novomexicana*.

2. *Lecanora nigromarginata* **Magnusson,**

Ann. Crypt. Exot. 5(1): 23 (1932). **TYPE:** U. S. A. Washington State. Yakima Co.: Cascade Mountains, upper Naches River region, May 1931 (June typed on label, but crossed out), *Grant 8604*, **Holotype** (including exact notes used in the original description) (UPS!) (Fig. 4).

Although the holotype of this taxon was not labelled by Magnusson as a new taxon, it is labelled in his writing as "*Lecanora (Placodium) nigromarginata* H. Magn." Magnusson stated in the original description that the collection was from "about 3100 ft." (= 925 m); this information presumably was sent in a letter from Grant (not seen). The holotype of *L. nigromarginata* appears distinct from the type of *L. novomexicana* in having larger, flatter, strongly black edged lobes that do not clearly radiate at the margin. We examined specimens from numerous herbaria, and collected extensively in the vicinity of the vaguely described type locality (a large and ecologically diverse area), but could find no material clearly matching the holotype. However, material that is very similar to the type except for having somewhat smaller lobes has been collected in British Columbia (Ryan 15094, ASU).

Specimens determined as "L. nigromarginata" in herbaria usually are misidentifications of Rhizoplaca melanophthalma, or sometimes L. semitensis (Tuck.) Zahlbr., both of which also occur in the vicinity of the type locality of L. nigromarginata. A few specimens resembling L. nigromarginata, especially from the Rocky Mountains, appear to be forms of L. novomexicana sensu lato. In the Northwest, where the type of L. nigromarginata was collected, typical L. novomexicana is very rare, and "L. thomsonii" is confined to a few scattered alpine localities.

Typical R. melanophthalma is distinguished from Lecanora nigromarginata by the former's usually peltate-foliose thallus with a well-developed lower cortex and more constricted apothecia with raised margins containing a double algal layer. There also may be differences in the asci (Ralph Common, pers. comm., 1988), which require further study. Rhizoplaca melanophthalma itself, however, as presently delimited, is extremely variable and probably represents a complex of taxa. In practice (partly because many specimens are fragmentary or strongly modified by snails or other environmental factors, and partly because of the subtlety of some of the characters), it is often very difficult to determinine to which species (and genus) much of the material resembling L. nigromarginata belongs.

The classification of L. nigromarginata presents some interesting problems. Poelt (1958), who saw only the holotype, chose L. nigromarginata as the type species of Lecanora sect. Petrasterion subsect. Pseudocorticatae Poelt, which could be problematic if the species is actually a Rhizoplaca! On the other hand, if L. nigromarginata and L. novomexicana, both published simultaneously, are actually conspecific, then one of the two names would be selected as the correct name for the species. Further critical study of the relationships among these various taxa is needed, however, to better resolve the problems. Lecanora nigromarginata is treated here as a separate taxon, but one of uncertain status and position.

Lecanora weberi Ryan,
Mycotaxon 36(1):9-14 (1989).

The relationship of this species to L. novomexicana was discussed briefly by Ryan (1989c). Unfortunately, the captions for Figs. 2 and 3 in that article are reversed: Fig. 2 is of L. novomexicana; Fig. 3 is of L. weberi. The specimens distributed in COLO Exs. 685 should be compared closely to the description and figures, since a few sets may include mixtures with Rhizoplaca melanopthalma. Lecanora weberi is one of several areolate-squamulose taxa that will be treated in more detail in a future article.

Excluded Taxon

Lecanora novomexicana B. de Lesd.,
Rev. Bryol. et Lichénol., n.s., p. 56 (1942), illegitimate name (Article 64.1), not L. novomexicana Magnusson (1932). **TYPE (from the protologue):** U. S. A. New Mexico. Santa Fe Co.: "Santa-Fe Cañon, 3100 m, silicole", undated, leg. Brouard. Not seen; probably destroyed during World War II.

The protologue of L. novomexicana B. de Lesd. does not mention specific specimens, but it states that the thallus is grayish white and areolate, with epruinose apothecia. Furthermore, Bouly de Lesdain placed this species in the genus Lecanora (rather than in Parmularia, which he used for lobate species) and stated that the species belongs to "stirpe Lecanora variae" (a non-lobate group in subg. Lecanora). Therefore this taxon is unrelated to the earlier L. novomexicana Magnusson. Because of the lack of a type and the vagueness of the description, it would be extremely difficult and probably unwise to create a new name for this taxon.

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THE DISTRIBUTION AND TAXONOMIC SIGNIFICANCE OF LICHENAN AND ISOLICHENAN IN THE PARMELIACEAE (LICHENIZED ASCOMYCOTINA), AS DETERMINED BY IODINE REACTIONS. I. INTRODUCTION AND METHODS. II. THE GENUS ALECTORIA AND ASSOCIATED TAXA.

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ABSTRACT: Methods are described for using a series of iodine reagents of differing composition to detect the presence of the polysaccharides lichenan and isolichenan in lichen thalli. All species studied of the genera *Alectoria, Bryoria, Coelocaulon, Cornicularia, Oropogon, Pseudephebe*, and *Sulcaria* are shown to have iodine reactions characteristic of lichenan, with the exception of *Bryoria* sect. *Subdivergentes*, and *Coelocaulon epiphorellum*. Lichenan was not detected in *Ramalina thrausta*. Lichenan is easily detected with these methods, and the distribution was found to be of taxonomic significance. Lichenan is found in high concentration in the thallus tissue of nearly all of the species in which it occurs. Isolichenan often appears to occur in very low concentration, and its distribution seems to be of less taxonomic significance. Isolichenan was found to have iodine staining characteristics that distinguish it from the blue staining material, here referred to as "amylomycan", associated with asci. A general review of polysaccharides known to have color reactions with iodine is provided. It is emphasized that a variety of different iodine reagents are necessary to distinguish among different iodine reactive materials, and that it is essential to accurately describe the techniques used when reporting iodine reactions as taxonomic characters.

KEYWORDS: Alectoria, Bryoria, Coelocaulon, Cornicularia, Oropogon, Pseudephebe, Ramalina, Sulcaria, lichenan, isolichenan, amylomycan, amyloid, iodine reagent, polysaccharide, cell wall, chemotaxonomy.

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INTRODUCTION

The blue color reaction of isolichenan (=isolichenin; the "-an" spelling is the accepted form in modern chemical literature) with iodine is well known, and has been used taxonomically in lichenology for many years. It has apparently escaped the attention of lichenologists, however, that lichenan (=lichenin) can also, under the proper conditions, form a colored complex with iodine. I have been interested in the iodine color reactions seen in lichen thalli since the late 1970s. While studying species belonging to the Parmeliaceae, I found that many specimens had a reddish reaction in the thallus. This reaction was seen only when the iodine concentration was relatively high, above approximately 1%, and was clearly distinct from the normal yellowish coloration seen in lichen tissue at this iodine concentration. When I found that the reaction was present in *Cetraria islandica* (from which lichenan and isolichenan were both first described), I began to suspect that the material giving the reaction was lichenan. Both lichenan and the I+ red material were major constituents of *C. islandica* hyphae, and both were soluble in hot water. Authentic samples of lichenan obtained from Sigma Chemical Co., isolated from lichens identified as *C. islandica* and *Usnea barbata*, had staining properties identical to the I+ red material seen in the lichen hyphae. The only clear reference to the I+ nature of lichenan was found outside the lichenological literature (Gaillard and Bailey, 1966). The staining of lichenan with iodine has subsequently been noted by Williams (1983), and Schlarmann (1987).

A comprehensive survey of species belonging to the Parmeliaceae s.l. (i.e.,including the segregate families Alectoriaceae, Anziaceae, Hypogymniaceae, and Usneaceae) was undertaken. Based on this work, a preliminary sketch of the lichenan distribution in this group was presented by Dr. H.A. Imshaug (1981) at the XIII International Botanical Congress in Sydney, Australia. At this meeting, preliminary data was released in the form of unpublished hand-outs (Common, 1981). These data described the major variants of lichenan that can be detected with iodine, and outlined the distribution of these staining variants within the genera then recognized. Several species or groups of species with aberrant reactions were noted. Subsequently, this information was cited in the publication of several new genera by Hale (1984, 1986a, and 1986b). This paper is the first of a series which will report the occurrence of lichenan and isolichenan within the species belonging to the Parmeliaceae s.l., and attempt to interpret the distribution of these polysaccharides in taxonomic terms.

Subsequent papers in this series will deal more strictly with the data relating to the taxonomic groups then under consideration. In this introductory paper, I have attempted to provide, in addition to a detailed description of the methods, a discussion of the importance of cell wall chemistry in the classification of fungi, including lichens. In addition, the phenomenon of iodine-polysaccharide interaction is reviewed. There is a great deal of literature on this subject, but it is dispersed among many fields, and is often difficult to find. I suspect that most mycologists and lichenologistls are unaware of the large number of naturally occurring materials that can give positive color reactions with iodine. Several of these materials are known to occur in lichens, and others may well be discovered in the future. My own research suggests that several distinct groups of I+ materials can be found in lichens, most of which have never been characterized chemically. I hope to examine the iodine reactions of groups outside the Parmeliaceae s.l. in future papers, but these reactions are beyond the scope of the present paper.

MATERIALS

IODINE REAGENTS

CALCIUM CHLORIDE - IODINE - POTASSIUM IODIDE (CaIKI) SOLUTION: A stock calcium chloride solution is prepared according to the following formula: calcium chloride (anhydrous) 44.4 g; distilled water to make 100 ml total volume. The working solution of CaIKI is made by combining this solution with 1.5% IKI in the proportion 9:1.

IODINE - POTASSIUM IODIDE (IKI) SOLUTIONS: All IKI solutions are expressed as percent iodine on a weight/volume basis; the weight of KI is twice that of the iodine unless otherwise indicated. Thus "1.5% IKI" indicates a solution prepared by dissolving 1.5g I_2 and 3g KI in enough distilled water to make 100ml total volume.

The solubility of iodine increases greatly as KI concentration is increased, so it is much quicker to dissolve the I_2 and KI first in a small amount of water, then dilute to the final volume. It is convenient to maintain a stock solution of concentrated IKI (e.g., 20%) and use this to prepare the other solutions by dilution. Iodine is very volatile, and solutions which are used frequently will rapidly loose strength (Baral, 1987). This is particularly true of very dilute solutions (e.g., 0.15%), which should be changed every few days.

I have found 0.15%, 1.5%, and 20% IKI solutions to be most useful. Intermediate concentrations may be useful for specific applications, such as determining thresholds of staining. I have not used commercially distributed IKI solutions such as Lugol's iodine, and can not confirm that their properties are identical to IKI solutions prepared as above.

LACTOPHENOL - IODINE - POTASSIUM IODINE SOLUTIONS (LPIKI): These are likewise expressed as percent iodine concentration on a weight/volume basis. The lactophenol solution used in this study is not of standard composition, in that no water is added. It is prepared according to the following formula: lactic acid, 60 g (50 ml); glycerine, 120 g (99 ml); phenol, 60 g. The reagents used in this study are 0.15% LPIKI and 0.4% LPIKI. They are made by mixing 20% IKI with the stock lactophenol solution in the appropriate proportion (1:133 and 1:50 respectively).

MELZER'S REAGENT: The reagent used here is prepared according to the original formulation (Melzer, 1924). Note that alternative formulations have occasionally been used by others, and may not have the same properties. Combine potassium iodide, 3.0 g; iodine, 1.0 g; chloral hydrate, 40.0 g; and distilled water, 40.0 ml. The total volume above is about 63 ml. Iodine concentration is approximately 1.6% on a weight/volume basis.

SULFURIC ACID - IKI SOLUTION (SIKI): This solution is essentially 1.5% IKI in a 5% sulfuric acid solution, except that a higher than usual KI concentration is used to make the solution more stable. Prepare 3% IKI solution by dissolving 0.45 g iodine and 3.0 g KI in water to make 15 ml solution; combine this with 15 ml of 10% H_2SO_4 to make the working solution of SIKI.

ZINC CHLORIDE - IODINE - POTASSIUM IODIDE SOLUTION (ZnIKI): A stock solution of zinc chloride is made by combining the following: zinc chloride, 100 g; potassium iodide, 35 g; distilled water, 60 ml. The working solution of ZnIKI is made by combining this solution with 1.5% IKI in the proportion 9:1. "Zinc-chlor-iodide" reagent is sold commercially, for example by Merck. This reagent is generally similar, but not identical to ZnIKI in its reactions, and some forms of lichenan appear to give different results with it.

OTHER MATERIALS

ACETIC ACID (DILUTE): A 2% solution is used.

BLEACHING SOLUTION: Commercially prepared laundry bleach (Clorox) with the active ingredient 5.25% sodium hypochlorite is used.

NITRIC ACID: Commercially obtained 70% reagent grade solution is used.

POTASSIUM HYDROXIDE: A 10% (weight/volume) aqueous solution is used.

LICHENAN: Practical grade lichenan from *Cetraria islandica* was obtained from Sigma Chemical Company, No. L-6133, lot no. 40F-0218. Lichenan from *Usnea barbata* was also obtained from Sigma, No. L-9003, lot no. 58C-02401.

ZINC CHLORIDE SOLUTIONS: Solutions of zinc chloride for presaturation of specimens to be tested in ZnIKI are made by diluting the stock zinc chloride solution used for making the ZnIKI reagent to half and quarter strength with water.

SPECIMENS EXAMINED

Most of the data reported here was gathered from a single specimen of each species. When possible, a collection that had been annotated by a monographer or other expert in the field, or an exsiccatum, was chosen. When unusual reactions were encountered, additional specimens were studied if possible. All specimens are from MSC unless stated otherwise.

ALECTORIA: ***A. imshaugii*** Brodo & Hawksw.: Imshaug 6088, Canada, Alberta (thamnolic acid +); Imshaug 16480, USA, Washington (squamatic acid +); ***A. lata*** (Tayl.) Linds: Tucker 6433, USA, California; Kurokawa 64022, Japan, Honshu; ***A. mexicana*** Brodo & Hawksw.: Pringle 195, Mexico, Oaxaca; ***A. nigricans*** (Ach.) Nyl.: Bormann, Cantlon & Rebuck 1054, USA, Alaska; ***A. ochroleuca*** (Hoffm.) Massal.: Imshaug 29034, USA, Alaska; ***A. sarmentosa*** (Ach.) Ach. subsp. ***sarmentosa***: Brodo 12913, Canada, British Columbia; ***A. sarmentosa*** subsp. ***vexillifera*** (Nyl.) Hawksw.: Kristensson 8034, Iceland (ASU); ***A. vancouverensis*** (Gyeln.) Gyeln. ex Brodo & Hawksw.: Ohlsson 825, Canada, British Columbia.
BRYOCAULON: ***B. divergens*** (Ach.) Kärnef.: Brodo 22308, Canada, British Columbia (ASU); Banfield 42, Canada, Quebec; ***B. pseudosatoana*** (Asahina) Kärnef.: Noble 7196, Canada, British Columbia (ASU); Kurokawa 64066, Japan.
BRYORIA: ***B. abbreviata*** (Müll. Arg.) Brodo & Hawksw.: Smith 16135B, USA, Idaho; Howell S 5318, USA, California; Tucker 14575, USA, California; ?Hamon 679-03A, USA, California (CANL); ***B. acanthodes*** (Hue): Kurokawa 268, Taiwan; ***B. bicolor*** (Ehrh.) Brodo & Hawksw.: Brodo 14295, Canada, British Columbia; ***B. capillaris*** (Ach.) Brodo & Hawksw.: Ohlsson 747B, Canada, British Columbia; ***B. cervinula*** Mot. ex Brodo & Hawksw.: Brodo 17769, Canada, British Columbia; ***B. chalybeiformis*** (L.) Brodo & Hawksw.: Taylor 1118, Canada, Nova Skotia; ***B. fremontii*** (Tuck.) Brodo & Hawksw.: Imshaug 7606, USA, Montana; ***B. friabilis*** Brodo & Hawksw.: Taylor 487, USA, Maine; ***B. furcellata*** (Fr.) Brodo & Hawksw.: Taylor 516, USA, Maine; ***B. fuscescens*** (Gyeln.) Brodo & Hawksw.: Wetmore 9899, USA, Wyoming; ***B. glabra*** (Mot.) Brodo & Hawksw.: Ohlsson 2710, Canada, British Columbia; ***B. implexa*** (Hoffm.) Brodo & Hawksw.: Wetmore 424, USA, Michigan; ***B. lanestris*** (Ach.) Brodo & Hawksw.: Wetmore 11702, USA, South Dakota; ***B. nadvornikiana*** (Gyeln.) Brodo & Hawksw.: Imshaug 4955, USA, Michigan; ***B. nitidula*** (Th. Fr.) Brodo & Hawksw.: Cantlon & Gillis 57-533, USA, Alaska; ***B. oregana*** (Tuck. ex Nyl.) Brodo & Hawksw.: Ohlsson 1590, Canada, British Columbia; Malachowski 289, USA, California; ***B. poeltii*** (Bystr.) Brodo & Hawksw.: Weber & McVean Lich. Exs. No. 346, New Guinea, Eastern Highlands; ***B. pseudofuscescens*** (Gyeln.) Brodo & Hawksw.: Imshaug 165, USA, Washington; ***B. simplicior*** (Vain.) Brodo & Hawksw.: Kucyniak 741, Canada, Hudson Bay (US); Imshaug 5972, USA, Montana; ***B. smithii*** (DR.) Brodo & Hawksw.: Ahlner s.n., MSC 143546, Norway; ***B. subcana*** (Nyl. ex Stiz.) Brodo & Hawksw.: Ullrich s.n., MSC 66748, Austria; ***B. subdivergens*** (Dahl) Brodo & Hawksw.: Alsstop 53-1975, Greenland (CANL); McCune 10042, USA, Montana (CANL); ***B. tenuis*** (Dahl) Brodo & Hawksw.: Brodo 10219, Canada, British Columbia; ***B. tortuosa*** (Merr.) Brodo & Hawksw.: Ohlsson 2887A, Canada, British Columbia; ***B. trichodes*** (Michx.) Brodo & Hawksw.: Ohlsson 2259, Canada, British Columbia; ***B. vrangiana*** (Gyeln.) Brodo & Hawksw.: Imshaug 6036, USA, Montana.
CANOMACULINA: ***C. pilosa*** (Stizenb.) Elix & Hale: Imshaug 42507, Uruguay; ***C. consors*** (Nyl.) Elix & Hale: Ferraro 250, Argentina (US).
CANOPARMELIA: ***C. caribaea*** (Hale) Elix & Hale: Le Gallo 2604, St. Barthéleme; ***C. inornata*** (Hale) Elix & Hale: Imshaug 22683, Haiti; ***C. martinicana*** (Nyl.) Elix & Hale: Imshaug 31565, Tobago; ***C. raunkiaeri*** (Vain.) Elix & Hale: Wetmore 3910, Dominican Republic.
CETRARIA: ***C. islandica*** (L.) Ach. ssp. ***islandica***: Cantlon & Gillis 57-769, USA, Alaska.
CETRELIA: ***C. cetrarioides*** (Delise ex Duby) Culb. & C. Culb.: Brodo 4977, Wales.
COELOCAULON: ***C. aculeatum*** (Schreb.) Link.: Nash 24930, Italy (ASU); Karenlampi & Raudaskoski, s.n., MSC 108591, Finland; ***C. epiphorellum*** (Nyl. in Crombie) Kärnef.: Imshaug 50581 & 52760, Argentina, Staten Island; ***C. muricatum*** (Ach.) Laundon: Imshaug 36301, Germany; ***C. steppae*** (Savicz) Barreno & Väzquez: Kotow s.n., MSC 59796, USSR, Ukraine.

CORNICULARIA:* *C. normoerica (Gunn.) Du Rietz: Nash 17321, Austria (ASU); Thompson & Frey, s.n., MSC 66544, Switzerland; Ohlsson 2806A, Canada, British Columbia.
EVERNIA:* *E. prunastri (L.) Ach.: Imshaug 36188, Tenerife.
FLAVOPARMELIA:* *F. caperata (L.) Hale: Imshaug 36771, Juan Fernandez.
GRAPHINA:* *G. mendax (Nyl.) Müll. Arg. Tucker 12084, USA, Louisiana.
HYPOGYMNIA:* *H. physodes (L.) Nyl.: Imshaug 60112, USA, Michigan.
IMSHAUGIA:* *I. aleurites (Ach.) S.F. Meyer: Imshaug 56338, USA, Michigan; ***I. placorodia*** (Ach.) S.F. Meyer: Imshaug 21153, USA, Michigan.
LETHARIELLA:* *L. canariensis (Ach.) Krog: Imshaug 35960, Tenerife; ***L. togashii*** (Asah.) Krog: Togashi s.n., MSC 94882, Japan.
MASONHALEA:* *M. richardsonii (Hook.) Kärnef.: Hanson s.n., MSC 76450, USA, Alaska.
OMPHALODIUM:* *O. pisacomensis Flot.: Roivainen 2730, Argentina (trace of lichenan detected); Imshaug 49891, Chile (no lichenan detected).
OROPOGON:* *O. atranorinus Essl.: Wetmore 3285, Haiti; ***O. bicolor*** Essl.: Wetmore 3499, Dominican Republic; ***O. caespitosus*** Essl.: Pringle 201, Mexico, Oaxaca; ***O. diffractaicus*** Essl.: Wetmore 3652, Dominican Republic; ***O. loxensis*** (Fée) Th. Fr.: Imshaug 13045, Jamaica.
PARAPARMELIA:* *P. annexa (Kurok.) Elix & Johnst.: Almborn 4410, South Africa; ***P. molybdiza*** (Nyl.) Elix & Johnst.: Hale 5835, South Africa; ***P. mongaensis*** (Elix) Elix & Johnst.: Hale 74213, South Africa; ***P. tortula*** (Kurok.) Elix & Johnst.: Almborn 4805, South Africa; ***P. xanthomelaena*** (Müll. Arg.) Elix & Johnst.: Almborn 276, South Africa.
PSEUDEPHEBE:* *P. minuscula (Nyl. ex Arnold) Brodo & Hawksw.: Nash 5249, USA, Utah (ASU); Imshaug 18808, USA, Montana; ***P. pubescens*** (L.) Choisy: Ohlsson 2973, Canada, British Columbia.
RAMALINA:* *R. thrausta (Ach.) Nyl.: Malachowski 1568A, USA, Michigan; Wetmore 1930, USA, Michigan; Imshaug 59290, Canada, Ontario; Imshaug 35815A, Tenerife; ***R. usnea*** (L.) R. Howe: Imshaug 25268, Cuba.
RIMELIA:* *R. cetrata (Ach.) Hale & Fletcher: Imshaug 23484, Dominican Republic; ***R. reticulata*** (Tayl.) Hale & Fletcher: Imshaug 36726, Juan Fernandez; ***R. simulans*** (Hale) Hale & Fletcher: Imshaug 22536, Haiti; ***R. subisidiosa*** (Müll. Arg.) Hale & Fletcher: Imshaug 24770, Cuba.
ROCCELLA:* *R. canariensis Darb.: Imshaug 33980, Tenerife; ***R. fuciformis*** (L.) DC.: Imshaug 35715, Tenerife.
SULCARIA:* *S. sulcata (Lév.) Bystr. ex Brodo & Hawksw.: Sato, Lichenotheca Japonica No. 4, Japan, Nara.
USNEA:* *U. rubsecens Stirt.: Imshaug 37315J, Juan Fernandez.
XANTHOMACULINA:* *X. hottentottum (Ach.) Hale: Almborn, MSC 147458, South Africa.
XANTHOPARMELIA:* *X. conspersa (Ehrh. ex Ach.) Hale: Imshaug 59570, Canada, Ontario.
XANTHORIA:* *X. parietina (L.) Th. Fr.: Brodo 5089, Wales; Huuskonen s.n., 25.IX.1959, Finland; Culberson & Culberson 12098, France; Taylor 2217, Newfoundland; Imshaug 25621, USA, New York.

METHODS

TERMINOLOGY: To be considered "iodine positive", a material should show distinct coloration, usually bluish or reddish, different from that of the iodine reagent itself. These staining reactions are given a designation in the form "I+ blue" or "I+ red", etc., in this paper. All lichen tissues show some degree of yellowish staining in most iodine solutions, with the intensity of the staining varying with the tissue and iodine concentration. This yellow or amber staining of tissue appears to represent simple absorption of iodine without complex formation, and is considered iodine negative, designated "I−". Terms such as "amyloid", (I+ blue), "dextrinoid" (I+ red), and "pseudoamyloid" (I+ brown, purple brown, red brown, or wine red; Singer, 1986), are generally avoided in this paper, as being unnecessary and possibly misleading.

GENERAL METHODS

The use of iodine staining reactions as taxonomic characters has a somewhat controversial history in mycology and lichenology. Most of the problems associated with these reactions have resulted not from variability within the species being studied, but from variations in the techniques used. In all too many cases, even in publications by modern workers, the methods used in obtaining iodine reactions are not given. Reactions may be changed by pretreatments with reagents such as KOH (Kohn and Korf, 1975; Nannfeldt, 1976). Results may also vary with iodine concentration, or be altered by the presence of other components of the reagent. Thus quite different results may be obtained depending on whether aqueous iodine-potassium iodine, Melzer's reagent, lactophenol-iodine, or other reagents such zinc chloride-IKI or calcium chloride-IKI are used. This problem has recently been discussed in detail by Baral (1987), and will be examined further here. The use of iodine in fungal and lichen taxonomy taxonomy has also been reviewed by Eriksson (1966), Watling (1971), and Singer (1986).

All tests described in this paper are performed on lichen thallus tissue which has first been decolorized with bleach (sodium hypochlorite). The relatively short treatment time necessary to bleach most lichen tissue does not seem to alter the iodine reactions. I do not believe bleaching actually induces any of the reactions, but many would remain undetectable otherwise because of the masking effect of naturally occurring pigments. Numerous hand sections are made from the dry or slightly wetted lichen thallus. These, along with unsectioned segments of branches or thallus lobes are placed in the wetting solution (95% ethanol) and then into the bleach. When possible, the sections should include as many different structures as possible. In the species under consideration here, it is important to include a few branch tips, since the reactions may be different in these areas. When studying other groups, include structures such as rhizinae, cilia, and margins, since these may stain differently. Also, sterile tissues in ascocarps sometimes have unique iodine reactions not found elsewhere in the thallus, and not related to the normal hymenial iodine reactions. Bleach for the minimum time necessary to decolorize the tissue. The sections are rinsed thoroughly in water, and kept wet until studied. Depression microscope slides can be used for these procedures. Sections are best handled with a dissecting needle, and larger tissue pieces with forceps.

Bubbles are sometimes retained in the tissue after bleaching. These will interfere with observation, and can be cleared by placing the sections in ethanol before storing them in water. When observing whole, unsectioned branch segments of *Bryoria*, etc., I have found it helpful to use the shaft of a dissecting needle like a rolling pin to force bubbles from the thallus while it is immersed in ethanol. In some cases, a heavy concentration of lichen substances may interfere with observations. The lichen substances can be removed by boiling the sections in ethanol or acetone without affecting the iodine reactions.

All observations are made with a compound microscope, with the specimen in a drop of the iodine solution. It is essential that the specimen be allowed to absorb as much iodine as it can from the solution. The tissue should be placed in a large drop of reagent and agitated thoroughly with a dissecting needle for at least 30 seconds. The reagent is then drawn off, replaced with a fresh drop of reagent, and the coverslip applied. **The aperture diaphragm in the condenser must be wide open, and the condenser height adjusted properly for Köhler illumination**. This is especially important for the observation of weak reactions, which may be completely obscured by diffraction when the aperture is closed even slightly. Weak, diffuse reactions, such as those frequently seen with isolichenan, should be viewed at low magnification (10X or lower objective). In some cases, the reactions seem most distinct when viewed with a dissecting microscope, but I would recommend that the reactions always be confirmed with a compound microscope, so that there can be no doubt as to what tissue is giving rise to the coloration. Sections should be as good as possible, since otherwise it may be difficult to identify the source of any coloration seen. I have found that "super stainless" teflon coated razor blades greatly facilitate hand sectioning. The sections should not be more than a few hyphae thick, or the reactions may be obscured or misinterpreted. If necessary, squash the tissue by tapping on the coverslip. This will help in interpreting the reactions, but structural information will be lost. The coloration of the solution itself may also interfere with observations. Weak reactions will be more distinct if there is a minimal depth of the solution on the slide. Reactions are best seen with a small amount of tissue well centered under the coverslip, to avoid drawing in air. Remove excess solution by squeezing and blotting with paper tissue.

It is sometimes possible to make observations of the same sections in several different solutions. The safest way to do this is to remove the coverslip and start the procedure over in the new solution. Never try to replace an iodine solution by placing the new reagent on one side of the coverslip, and drawing the old solution off from the other side with a blotter. This technique will result in poor mixing, and equilibrium with the new solution will not be reached.

When testing the same section with different solutions, the order in which the solutions are applied is very important. For example, an ascending sequence of IKI concentrations may not give the same results as a descending sequence. Some solution changes may result in false positives which may or may not be of interest, and could be very misleading if not understood. A very useful false positive is seen in the 20%→0.15% IKI test described below. Another false positive is seen with the *Cetraria* form of lichenan in ZnIKI. When *Cetraria*-type lichenan is run through an ascending concentration series of zinc chloride solutions and placed in ZnIKI, it is negative, but if transferred from 1.5% IKI to ZnIKI it will have a red reaction that is at least semi-stable. In general, once an iodine complex is formed, it is sometimes semi-stable in a reagent in which the complex would not form directly. This effect should not be confused with poor penetration of the new reagent, since the semi-stable reactions last for hours or days even with extended agitation in the new solution.

Testing of the same tissues in different reagents should therefore be restricted to certain cases. It is appropriate to test tissues in an ascending series of concentrations to find thresholds of staining, but not in a descending series unless the contrasting result is itself of interest. Likewise, transfers from IKI to any of the other reagents (Melzer's, LPIKI, ZnIKI, CaIKI) should be considered as separate tests, not necessarily equivalent to direct immersion in the reagent. In this study, separate sections or thallus fragments were used for scoring of reaction types in 0.15% IKI, 1.5% IKI, Melzer's reagent, CaIKI and ZnIKI. The same tissue used for the 0.15% IKI test was transferred to 0.15% LPIKI and observed. Separate specimens were used for any additional tests performed.

TESTS FOR LICHENAN

PRECIPITATION TESTS FOR LICHENAN ("h-1.5% IKI" and "h-SIKI"): These tests involve heating (thus the "h" in the abbreviation) tissue in a drop of an iodine solution to see if an I+ precipitate forms on cooling. They can be performed on sections or small fragments of thallus tissue, and work on either bleached or unbleached tissue. The tissue is placed on a microscope slide, in a large drop of SIKI or 1.5% IKI, and agitated as usual. The coverslip is applied so that the tissue is in the center. There should be ample reagent for this test, so that the slide does not dry out when heated. The slide is placed on a hotplate, with the temperature adjusted to slightly over the boiling point. When the temperature is adjusted correctly, the solution will begin to boil gently in about 20-30 seconds. Note that if the temperature is too high, violent boiling may occur, which will not only ruin the test, but could be dangerous. When the slide has boiled for 2-3 seconds, remove it and allow it to cool for several minutes before observing. Excessive boiling must be avoided, so that the iodine concentration does not become too low for the I+ precipitate to form. With 1.5% IKI, *Cetraria*-type lichenan forms a cloud of fine, bright red granules around the specimen. With SIKI, both the *Cetraria*- and

Xanthoparmelia-type lichenans form a cloud of coarser, darker granules. In either solution, a fine precipitate of colorless or yellowish material, presumably an iodine negative polysaccharide, may be seen in addition to, or instead of, the lichenan precipitate. These iodine negative precipitates usually take longer to form than the I+ red lichenan precipitate. Several lichen substances, most notably stictic acid, can also form I+ red or blue precipitates in these reagents. Stictic acid is easily distinguished, forming radial clusters of extremely fine needle-like crystals. Lichens with fatty acids will form an abundance of yellow oily droplets with the SIKI test.

The iodine-lichenan complex does not seem to form when the lichenan is in the dissolved state. If the slide is observed microscopically as it cools, a distinct shift in color from yellow to red is seen when the precipitate begins to form. This is illustrated in Figures 1a-1c.

***CETRARIA*-TYPE LICHENAN:** Lichenan is, by definition, the hot-water extractable polysaccharide present in high concentration in *Cetraria islandica*. Lichenan from this species is I− in 0.15% IKI, but is distinctly reddish in 1.5% IKI. The threshold of staining is about 1%. If calcium chloride is added to the solution, the threshold of staining is greatly reduced. Intense red coloration is seen in CaIKI, which has the same iodine concentration as 0.15% IKI. When zinc chloride is added to IKI, the situation is more complex. When a small amount of zinc chloride is added, the threshold of staining is reduced. But when the concentration of zinc chloride becomes very high, as with the ZnIKI reagent, the staining is suppressed completely. In Melzer's reagent coloration is yellow-orange, not distinctly red. There is no coloration attributable to the lichenan in 0.4% or 0.15% LPIKI after prestaining in 1.5% IKI (but note that it will take some time for the excess iodine to be released from the specimen). Treatment with KOH causes the polysaccharide to become gelatinous. After the KOH has been rinsed out (a dilute acidic solution, e.g. 2% acetic acid, is best to avoid washing away the polysaccharide), the lichenan forms a gel with essentially the same staining characteristics as before. It is not converted to a form that stains blue in IKI solutions of any concentration. When heated to boiling in either 1.5% IKI or SIKI ("h-1.5%IKI" and "h-SIKI" tests), a very abundant red precipitate forms on cooling.

The above characteristics have been confirmed in both commercially obtained lichenan isolated from *C. islandica*, and from thallus sections of the lichen. Observations from the thallus are complicated by the presence of a high concentration of isolichenan. The commercially obtained extract is somewhat contaminated, but the major fraction of this product clearly has the staining properties described above. The contaminant is I+ blue in 0.15% IKI and does not dissolve nearly as rapidly as the lichenan with boiling; it is present in physically separate granules, and probably consists of a mixture of isolichenan, or possibly starch from the phycobiont, and iodine negative polysaccharides. Commercially obtained lichenan from *Usnea barbata* was also tested, and had identical properties.

The features defined above characterize the iodine staining patterns of the lichenan-like polysaccharides found in most of the genera of the Parmeliaceae s.l. that show positive "lichenan" reactions. There are significant differences seen in some genera, however, most notably in *Xanthoparmelia* and related taxa.

***XANTHOPARMELIA*-TYPE LICHENAN:** As with the *Cetraria*-type lichenan, no coloration is seen in 0.15% IKI and red coloration is seen in 1.5% IKI. In Melzer's reagent, in contrast to the orange color seen with *Cetraria*-type lichenan, a distinct reddish coloration is visible. Coloration is intense red in CaIKI, but unlike the *Cetraria* type, a strong purple color is visible in ZnIKI, even after saturation with zinc chloride solution as described below. Treatment with KOH or nitric acid causes some gelatinization, but not as much as with the *Cetraria* type. An abundant red precipitate is obtained with the h-SIKI test, but only a trace of red precipitate is seen with the h-1.5% IKI test, apparently indicating a reduction in the rate at which it dissolves in boiling water.

Since this type of "lichenan" differs significantly from the *Cetraria*-type in its iodine staining, it may be questioned whether this material should be identified with lichenan at all. The reasons for believing it should be are listed below:

1. One species, *Xanthoparmelia conspersa*, which shows staining typical of the *Xanthoparmelia* type, has been studied by conventional macrochemical techniques and found to contain a polysaccharide identified as lichenan (Shibata, 1973a).
2. The two reaction types are seen only within the Parmeliaceae s.l., occur in homologous tissue types, and are seen in the same location within the hyphal cell wall, i.e., the secondary thickening.
3. Both forms show the unusual feature of remaining unstained in IKI solutions of concentrations below about 1%, though the threshold of staining seems to be a little lower in the *Xanthoparmelia* type.
4. Some species from several different genera have lichenan which is intermediate in its staining reactions. Many of these species show variability of staining type within a thallus, so that typical *Cetraria*-type lichenan is seen in some structures, and lichenan approaching the *Xanthoparmelia* type is seen in others.

THE 20%→0.15% IKI TEST FOR TYPE OF LICHENAN: Perhaps the most striking difference between the two principal forms of lichenan is seen with this test. The bleached sections are placed in 20% IKI for about one minute, rinsed in 1.5% IKI, and then in 0.15% IKI. The intermediate rinse helps to prevent the precipitation of elemental iodine in the section. It is very important to agitate the specimen in 0.15% IKI until equilibrium has been reached, particularly if the section or thallus fragment is thick, since iodine is released from the complexed lichenan slowly. *Cetraria*-type lichenan loses its red coloration relatively soon in 0.15% IKI, becoming colorless. With the *Xanthoparmelia* type, however, an impressive blue coloration that is quite stable remains after the excess iodine is washed away. This induced coloration lasts for at least several days if the specimen is placed in a sealed container to prevent iodine loss. It should be emphasized that no blue staining is seen when sections are placed directly into the 0.15% solution, and none develops even after several days of immersion in the reagent. This blue coloration should not be confused with isolichenan. A direct comparison of a section pretreated with 20% IKI should be made in 0.15% IKI with one placed directly in the reagent, which acts as a control. The blue coloration induced by pretreatment with 20% IKI is in one sense a false positive, since it does not form directly in the reagent in which it is observed, and is probably not completely stable. It does, however, reliably distinguish the two principal forms of lichenan. Both the *Cetraria* and *Xanthoparmelia* types of lichenan require high iodine concentration to form a complex, but, once formed, the *Xanthoparmelia*-type lichenan-iodine complex is much more stable at lower iodine concentration.

KOH AND NITRIC ACID PRETREATMENT TESTS FOR TYPE OF LICHENAN: As noted above, gelatinization of tissue containing lichenan occurs with these reagents. The tests should be performed on moderate sized fragments of tissue (approx. 1mm square). After the tissue has been wetted with the reagent (10% KOH or 70% HNO_3), all excess reagent is blotted away and the tissue is macerated. After 1 minute, the tissue is transferred to the appropriate iodine reagent. With nitric acid pretreatment, use 1.5% IKI; with KOH, use SIKI. Let the specimen stand, with gentle agitation, until it has become completely stained. Transfer to 0.4% LPIKI and agitate until no further loss of iodine from the specimen can be seen. Equilibrium is often not reached immediately, and the slides should be kept a day or two for further observation. *Cetraria*-type lichenan loses its coloration from the IKI solution relatively rapidly in these tests, whereas Xanthoparmelia-type lichenan has a distinct purplish color that is retained for a day or more. These tests are messy and somewhat imprecise, and have largely been superceded by other tests (such as ZnIKI and 20%→0.15% IKI) adopted later in the course of this study.

They do, however, seem to be quite sensitive to minor variations in lichenan composition. Most notable is the persistent, distinctly reddish coloration seen after nitric acid pretreatment in *Cornicularia*, *Pseudephebe*, and *Lethariella*.

"TRUE" AND "FALSE" REACTIONS IN ZnIKI: When lichenan-containing specimens are placed directly (after bleaching and wetting) into ZnIKI, red reactions are often seen that are uneven in distribution and coloration, seeming to depend more on the density of the tissue or thickness of the specimen than on the tissue type. These reactions may be seen in the middle of tissue fragments, but not in identical tissue at the edge, or may occur in thick sections, but not in thin sections from the same area. They often surround an area of tissue that looks refractive, and has apparently been desiccated by the extremely hygroscopic solution. These reactions seem to be caused by disequilibrium conditions which occur while the reagent is penetrating the specimen. Recall that the threshold of staining for lichenan is reduced by moderate zinc chloride concentration, but staining is inhibited at high concentration. Also, note that the lichenan-iodine complex is semi-stable in ZnIKI if it has been allowed to form in another solution. Complex formation apparently occurs in areas of reduced zinc chloride concentration as the reagent penetrates the specimen, and persist after the reagent has fully penetrated the tissue.

These reactions are thus "false" in the sense that they are not formed directly in the reagent in use, but rather under undefined transitory conditions that exist when the specimen is first placed in the reagent. If tissue from a specimen which shows a false reaction when placed directly in ZnIKI is instead run through a series of zinc chloride solutions (25%, 50%, and then full strength, to avoid desiccation of areas of the specimen), and then immersed in ZnIKI, no reaction is seen. This pretreatment does not inhibit the purple reaction seen with the *Xanthoparmelia*-type lichenan. I have experimented with a more dilute zinc chloride-iodine solution made by mixing ZnIKI with an equal volume of water. This solution gave generally similar results and was less likely to cause dehydration, but also gave false reactions.

False reactions are inconvenient, but are easy to recognize with a little experience. Doubtful cases should be checked with the zinc chloride pretreatment. Certain groups, notably some species of *Coelocaulon*, seem much more prone to give these reactions than others. These effects probably result from minor variations in lichenan structure, perhaps reflecting a lower threshold of staining. It is likely that other reagents could be devised to better detect such minor variations in structure, and to distinguish between the major forms of lichenan without these problems. Despite the problems associated with its use, the ZnIKI reagent is too useful to abandon until a superior replacement can be developed.

TESTS FOR ISOLICHENAN

Isolichenan has a positive reaction, with a lilac to lavender coloration, in all of the iodine reagents used in this study. The reactions are often extremely weak, due either to low concentration of isolichenan, or perhaps to the presence of variant forms of the polysaccharide having a lower affinity for iodine. Isolichenan reactions are not equally visible in all reagents. In IKI, particularly at higher concentrations, the weak reactions are obscured by the normal yellowish (I−) background staining. Because blue and yellow are complementary colors, the combined effect is an inconspicuous gray instead of distinctly bluish. The same problem is seen in CaIKI and Melzer's reagent. Isolichenan never becomes red when the IKI concentration is increased.

The best procedure for demonstrating the isolichenan-type reaction is as follows:

1. Bleach and wet as usual. Remove all bubbles with ethanol, and if lichen substances are present in high enough concentration to interfere with observation, remove by boiling sections in ethanol or acetone.

2. Stain the section in 0.15% IKI.
3. Transfer to 0.15% LPIKI and agitate.
4. Coverslip, and observe under low magnification (10X objective) with the microscope illumination properly adjusted as described below.

Isolichenan probably does not stain more intensely in LPIKI. The advantage of the LPIKI solution for observing isolichenan lies in its effect as a clearing agent. The high refractive index lessens the refraction caused by hyphae, making the faint reactions more visible. Also, yellow background staining of the tissue is much less in this reagent than in any other I have used. Reactions that are difficult to see in IKI or other reagents will appear strong and distinct. Unfortunately, there are many species with very weak reactions which remain difficult to score as positive or negative even with this procedure. Years of experience have sensitized me to these faint reactions, which I am sure that in many cases, other workers will find difficult to see. It might seem convenient to ignore these marginal reactions, but I see no way to do so. There is a complete continuum of intensities from strong, through faint but definite, to cases where there is only an impression of coloration that can not be definitely scored positive. The "comfort zone" in scoring these reactions as positive will vary between workers, and there is no place to draw the line between distinctly positive, and uncertain specimens. The weak reactions will be completely invisible if the aperture diaphragm is partially closed, as it normally is for routine observations of other kinds. Also, light scattering from hyphae or lichen substances produces an effect that is difficult to distinguish from faint isolichenan reactions. Weak reactions are often seen better in somewhat thicker sections, or in whole branches or lobes. Isolichenan is also frequently very uneven in its distribution. In *Alectoria* and *Bryoria*, it is often stronger in the older parts of the thallus. In other groups, the reaction may be restricted to special structures, such as thallus margins, branch tips, or the sterile elements of the ascocarp (but not the asci or ascogenous hyphae).

Isolichenan has often been identified with the I+ blue material present in asci and ascogenous hyphae. These latter reactions represent a clearly distinguishable class of polysaccharides, as will be discussed in detail below (see "discussion" section).

PROBLEMS ASSOCIATED WITH IODINE TESTS

The following are some of the more likely sources of error that may arise when performing iodine tests.

1. Reagents which are too old, and have lost iodine through evaporation.
2. Improper adjustment of the microscope. The aperture diaphragm should be wide open, and the condenser height adjusted for Köhler illumination. This is extremely important when viewing weak reactions. Weak, diffuse reactions are best seen at low magnification, whereas very strong reactions can be studied at higher magnifications to determine the exact location of the I+ material.
3. Specimen not in equilibrium with the reagent, due to insufficient agitation.
4. Tissue too thick, so that either subtle coloration is obscured, or normal yellowish coloration seen in I− tissues is misinterpreted as I+ red.
5. Failure to identify the source of reactions. Green algae (the phycobiont) usually contain blue staining starch granules, and reddish or bluish staining of the cellulose of their cell walls is seen in many of the iodine reagents. Specimens may be contaminated with fragments of another lichen, or be parasitized by a fungus with I+ hyphae. Several lichen substances, most notably stictic acid, can also form strongly colored iodine complexes.
6. In precipitation tests, insufficient or excessive boiling of the solution.
7. Mixed reactions. In many cases, the mycobiont may have more than one type of

I+ polysaccharide present in the cell walls. Often the reactions are seen in different tissues, but sometimes the reactions occur together in the same hyphae, as is seen with lichenan and isolichenan in most of the species covered in this paper. In some cases, as with lichenan and isolichenan, the properties of the reacting substances can easily be separated and attributed to the appropriate substance. In other cases, however, it can be difficult to distinguish how many reactive materials are present, and which properties belong to which material.

RESULTS

***ALECTORIA*:** Isolichenan-like reactions were seen in all specimens, though the strength varied, for example being quite weak in *A. lata* (Kurokawa 64022) and quite strong in *A. nigricans*. The reactions are strongest in the inner part of the cortex. In most of the species, the isolichenan reaction is quite diffuse. In *A. sarmentosa* subsp. *vexillifera*, however, numerous hyphae having intense purplish reactions with the characteristics of isolichenan were scattered throughout the cortex in the older areas of the thallus. The irregular I+ deposits were tightly appressed to the primary cell wall of the hyphae, which were contorted and thin walled, unlike the majority of the cortical hyphae in morphology.

All specimens had a strong red reaction in CalKI. *Alectoria lata* (Kurokawa 64022) had a distinct, very thin I− region at the surface of the cortex (Fig. 1d), with the rest of the cortex, and the medulla, being strongly positive. In the other species studied, the cortex was more eroded, and an outer I− layer was indistinct, discontinuous, or not evident at all. The ornamentation of the medullary hyphae was stained red (Fig. 3e). All species had abundant red precipitate in the h-1.5% IKI test. In ZnIKI many species had no reaction, or a typical false red reaction in inner, poorly penetrated areas of the cortex. Several species, however, have trace amounts of lichenan which differ from the *Cetraria* type in staining reactions. This unusual lichenan is usually present in scattered hyphae, often best developed near the tips of branches. In *A. nigricans*, there are numerous hyphae on the surface of the thalli which stain red in ZnIKI before pretreatment, but not after pretreatment in zinc chloride solutions. No red reaction was seen in Melzer's reagent, no induced blue after 20%→0.15% IKI, and no red in LPIKI after pretreatment with nitric acid and 1.5% IKI. The reaction is thus false, but is seen on individual hyphae not associated with desiccated areas, and resembles true reactions seen in other species in appearance and location. Similar hyphae in *A. mexicana* had a positive reaction after nitric acid pretreatment, and were distinctly red in Melzer's reagent; the ZnIKI test was negative after pretreatment with zinc chloride solutions, and no induced color was seen after 20%→0.15% IKI. Similar hyphae are present in *A. vancouverensis* and *A. sarmentosa* subsp. *vexillifera*. These hyphae are red in Melzer's reagent and ZnIKI. In these species, however, traces of positive reactions were also seen with the 20%→0.15% IKI test, and a small amount of red was seen in ZnIKI after pretreatment with zinc chloride solutions, although most of the red reaction was eliminated by pretreatment. In *A. sarmentosa* subsp. *vexillifera*, the induced blue from the 20%→0.15% IKI test is difficult to see because of the unusual distribution of isolichenan in this specimen. The isolichenan can be distinguished by the differing morphology of the hyphae on which it occurs. In A. *sarmentosa* subsp. *sarmentosa*, in an old part of the thallus, a mixture of lichenan positive and lichenan negative hyphae were seen in the cortex (Fig. 3f). In younger parts of the same thallus, the cortical hyphae were uniformly strongly lichenan positive. I have not attempted to determine if the differences seen between the subspecies of *A. sarmentosa* are consistent, or if they warrant a reconsideration of the status of these taxa. It appears that several *Alectoria* species have lichenans which, to different degrees, approach the *Xanthoparmelia* type in staining characteristics. The bulk of the lichenan in these species, and all of the lichenan in the other species, has the properties of the *Cetraria* type.

***BRYOCAULON*:** An isolichenan-like reaction was moderately well developed in both *B. divergens* and *B. pseudosatoana*. In both, the inner part of the cortex, and the medulla were reactive. Lichenan was present in the cortex, except for a thin outer layer, and in the medullary hyphae. Ornamentation was seen on the medullary hyphae, and was lichenan positive (Fig. 4d). Abundant red precipitate was seen in the h-1.5% IKI test. No true positive reaction was seen in ZnIKI, and there was no induced blue coloration with the 20%→0.15% IKI test. Thus, only *Cetraria*-type lichenan was detected. In older portions of the specimen of *B. divergens* studied, many thin walled lichenan negative hyphae were seen in the medulla, sometimes forming bundles or strands.

***BRYORIA*:** Isolichenan-like reactions were seen in all species studied, with the possible exception of *B. poeltii*, which has an unusually difficult to bleach pigment that interferes with observation. The strength of the reaction varied considerably, being very weak in some specimens, notably that of *B. capillaris*, and quite strong in others, for example, *B. implexa*. In most species the reaction was relatively weak, but definitely visible in 0.15% LPIKI. The reactions are consistently strongest in the inner part of the cortex, and in the medulla. Old parts of the thallus are usually more strongly positive, and the reactions are often not visible at all in the tips of branches. The strength of the reaction may vary considerably from thallus to thallus within a collection.

Lichenan was conspicuously absent from three species, *B. abbreviata*, *B. oregana*, and *B. subdivergens*. These species all belong to *Bryoria* sect. *Subdivergentes*. All other species had very strong reactions characteristic of *Cetraria*-type lichenan. Abundant I+ red precipitate was seen with the h-1.5% IKI test, and strong red color in CalKI. The cortex is always strongly reactive, and the medulla strongly to weakly reactive. A distinct I− zone on the surface of the cortex, containing a continuous layer of I− hyphae, was seen in only one specimen, that of *B. trichodes*. In the other specimens, the I− zone was either absent, reduced to a discontinuous layer consisting of scattered I− hyphae (Fig. 3b), or present only as a very thin extracellular layer without embedded I− hyphae. I have not attempted to determine if these variations are useful taxonomic characters, or more likely, related to the age and condition of the area sectioned. I have noted distinct differences in the appearance of sections seen in CalKI taken from different parts of the same thallus. In young areas, the cortex is always densely, uniformly red in CalKI, whereas in older areas, there is sometimes an increase in I− or weakly I+ red matrix material between the hyphae. These areas seem to be more brittle. The medullary hyphae are sometimes strongly lichenan positive, sometimes only weakly so. Ornamentation of the medullary hyphae is usually not as well developed as in *Alectoria*, but was seen in many species, being especially prominent in *B. chalybeiformis, B. glabra*, and *B. pseudofuscescens*. When bumps or protrusions are present, they are I+ red in CalKI. The medullary hyphae also varied considerably in diameter from specimen to specimen, with the thinner hyphae tending to have weaker lichenan reactions. Again, I have not attempted to assess the consistency of these variations at the species level. False red reactions were common in ZnIKI. These reactions were eliminated by pretreatment with zinc chloride solutions. One species only, *B. vrangiana* (sensu Brodo and Hawksworth, 1977), had a very weak true red reaction in ZnIKI. The I+ red hyphae were in the cortex, mostly in segments lacking algae, and were not seen in branch tips. These hyphae were very few and inconspicuous. Pretreatment with zinc chloride solutions did not eliminate the reaction. In the 20%→0.15% IKI test a few hyphae seemed to be I+ purple, but the presence of the isolichenan reaction made interpretation uncertain.

A very unusual type of iodine reaction was seen in the members of *Bryoria* sect. *Subdivergentes*. A trace of reddish material associated with some hyphae in the outer part of the cortex was seen in ZnIKI, in a specimen tentatively referred to *B. abbreviata*, Hamon 679-03A (Brodo and Alstrup, 1981). In CalKI and Melzer's reagent, the faintest traces of reddish color could be seen in some areas, but most areas were negative, and the reaction was clearly less well developed than in ZnIKI. To study the properties of this reaction further, adjacent areas of the thallus were bleached as usual, placed in 20% IKI for one minute, rinsed in 1.5% IKI, and transferred to ZnIKI. There was now a very well developed red reaction in the outermost layer in the cortex of most areas of the thallus. The material was present in irregular deposits on the surface of the thallus, and between hyphae in the outermost part of the cortex. This material differs from lichenan in several respects:

1. The material is negative or virtually so in CalKI and 1.5% IKI. Most of the material is also negative in ZnIKI.
2. After pretreatment with 20% IKI, the material is strongly positive in CalKI, 1.5% IKI, Melzer's reagent, and ZnIKI. The reaction seems to be stable for a period of at least a day after these treatments.
3. There was no I+ red precipitate with either the h-1.5% IKI, or the h-SIKI tests.
4. With the 20%→0.15% IKI test, there was no persistent color, as would be expected with a ZnIKI positive form of lichenan.
5. The material was present in the surface layer of the cortex, the location where lichenan is least well developed in most of the other species and genera of this study.
6. The reaction was completely eliminated by pretreatment with 10% KOH for one minute, but appeared to be unaffected by pretreatment for one minute in 70% nitric acid.

The other species of section *Subdivergentes* were restudied with the 20% IKI→1.5% IKI→ZnIKI technique to determine if this material was present. In *B. subdivergens*, a positive reaction was found in trace amounts only, at the tips of young branches, in Alstrup 53-1975, but no reaction was seen in McCune 10042. In *B. oregana*, the reaction was moderately well developed in Malachowski 289, but only traces were seen in Ohlsson 1590. In *B. abbreviata*, a very well developed reaction was seen in Tucker 14575, and moderately well developed reaction was present in Smith 16135b and Howell S 5318. In general, the reactions were quite variable within a collection, being well developed on some thalli or parts of thalli, and absent or poorly developed in other areas. Other species of *Bryoria* have not been studied with this technique. This matter will be addressed in more detail in a paper dealing with the taxonomic status of *Bryoria* sect. *Subdivergentes*, in near future.

COELOCAULON: No definite isolichenan-like reaction could be seen in *C. steppae*. In *C. epiphorellum*, a reaction is probably present, but was so weak as to leave some uncertainty. In *C. aculeatum* and *C. muricatum* light but distinct isolichenan-like reactions were present, located in the inner layer of the cortex.

The lichenan reactions of the species showed significant variation. Most interestingly, *C. epiphorellum* was completely negative for lichenan with all tests. In *C. aculeatum* and *C. steppae*, a strong red reaction was seen in CalKI throughout both the inner and outer cortical layers, except for a very thin layer at the surface (Fig. 4b). The medullary hyphae were positive. In *C. muricatum*, however, the outer I− region of the cortex was much thicker than usual, and the anticlinal hyphae which make up the outer cortical layer could clearly be seen to have strongly I+ red inner walls, suspended in an I− matrix (Fig. 3d). The three lichenan-positive species all had abundant red precipitate with the h-1.5% IKI test. In ZnIKI these three species all had a reddish reaction in the inner layer of the cortex. The reaction was weak in *C. muricatum*, relatively strong in the other two species. When sections or whole lobes were pretreated with zinc chloride solutions, the reactions were completely eliminated. Thus, these reactions are technically false, but they are much more uniform and repeatable than typical false reactions seen in the other genera of this study. They were seen even in thin, evenly penetrated sections. No induced blue coloration was seen in the 20%→0.15% IKI test. These species also gave ambiguous or intermediate results after sequential treatment with nitric acid, 1.5% IKI, and 0.4% LPIKI: a persistent reddish color was seen, as opposed to no color with the typical *Cetraria*-type lichenan, or a purple color with the *Xanthoparmelia* type. Thus, it appears that these species contain a variant of lichenan in the inner cortex which has characteristics somewhat intermediate between typical lichenan and the *Xanthoparmelia* type.

CORNICULARIA: The iodine reactions of *C. normoerica* were unusual and distinctive. No isolichenan-like reaction was detected in the three specimens studied. In CalKI the medullary hyphae and most of the cortex, including the thick cartilaginous matrix material, is stained dark red; only the outermost layer of the cortex was negative (Fig. 2a). In ZnIKI there is a strong red reaction, clearly a true positive that can be seen in the thinnest sections and on individual hyphae, and is not inhibited by pretreatment with zinc chloride solutions. The reaction is restricted to a layer closely appressed to the primary wall of the hyphae (Fig. 2b) and is present on hyphae throughout the cortices. It appears to have a fibrillar texture, radiating away from the surface of the hyphae (Fig. 1e). The bulk of the matrix material is negative in this reagent. There is also a well developed red reaction in Melzer's reagent, and in the 20%→0.15% IKI test, there is a strong persistent purple reaction with the same distribution as seen in ZnIKI. A heavy I+ red precipitate is seen with the h-1.5% IKI test. Thus it appears that most of the cortical matrix is composed of typical *Cetraria*-type lichenan, but that a material similar to the *Xanthoparmelia* type is present in a thin layer just outside the primary wall of the cortical hyphae. The reactions of this material are not identical to the typical *Xanthoparmelia*-type lichenan, however: the staining looks more purplish after the 20%→0.15% IKI test, and more reddish in ZnIKI than is seen in *Xanthoparmelia*. As in *Coelocaulon*, persistent reddish staining is seen after sequential treatment in nitric acid, 1.5% IKI, and 0.4% LPIKI.

OROPOGON: No isolichenan was seen in *O. atranorinus*, *O. diffractaicus*, or *O. loxensis*. There was a faint suggestion of purplish color in *O. bicolor*, too uncertain to score positive. In *O. caespitosus,* a light but definite isolichenan-like reaction was present in the inner cortex. The tests for lichenan were similar for all the specimens. In CalKI the cortex has a thin outer I− region, with most of the cortex dark red (Fig. 4a). The secondary wall of the cortical hyphae can be seen to have multiple layers of I+ red material (Fig. 4c). The medullary hyphae were lighter red. Abundant red precipitate was seen in the h-1.5% IKI test. No true reactions were seen in ZnIKI, and there was no induced color with the 20%→0.15% IKI test. Thus, only typical *Cetraria*-type lichenan was detected.

PSEUDEPHEBE: Isolichenan could not be detected with certainty in any of the specimens studied. The bulk of the cortex gave a strong red color in CalKI, with only a very thin outer I− zone (Fig. 3c). There is abundant red precipitate in the h-1.5% test. In ZnIKI there was a distinct red reaction, clearly a true positive, restricted to somewhat irregular looking deposits on hyphae in the outer layer of the cortex, just below the I− zone. The same areas gave a positive purple color with the 20%→0.15% IKI test, and a distinctly red coloration in Melzer's reagent, as opposed to the more orange color elsewhere. In *P. pubescens*, the reaction was seen mostly at the tips of branches. In *P. minuscula*, the reactive material was more widespread, but still best developed at the branch tips (Fig. 1f). Thus, the situation is similar to that seen in *Cornicularia*, except that the material similar to *Xanthoparmelia*-type lichenan is much less abundant, and restricted to a thin outer layer of the cortex. A reddish coloration was seen in *P. minuscula* with the nitric acid→1.5% IKI→0.4% LPIKI test.

RAMALINA: At this time, I am only reporting on *R. thrausta*, which closely resembles *Alectoria* in growth form. This species was incorrectly reported as being lichenan positive (Common, 1981) based on study of a mixed collection in which a portion of a thallus belonging to *Alectoria* sp. was inadvertently tested. *Ramalina thrausta*, along with all other *Ramalina* species studied, is lichenan negative. A typical isolichenan-like reaction is present, however, in this species, as well as some others in the genus.

SULCARIA: A pale but distinct isolichenan-like reaction was seen in both specimens of *S. sulcata* studied; the reaction was seen in the inner part of the cortex, and in the medulla. This reaction is best seen in sections, due to interference from the granular deposit in the cortex when viewing whole lobes. In CalKI a strong red reaction was seen in the medulla, and in all but a very thin outer layer of the cortex. The tissue filling the sulcus is mostly negative. A heavy I+ red precipitate forms in the h-1.5% IKI test. In ZnIKI no true red reactions were seen in any tissue, though false reactions were seen in a few areas when whole lobes were studied. Thus, only typical *Cetraria*-type lichenan was detected.

EXPLANATION OF FIGURES

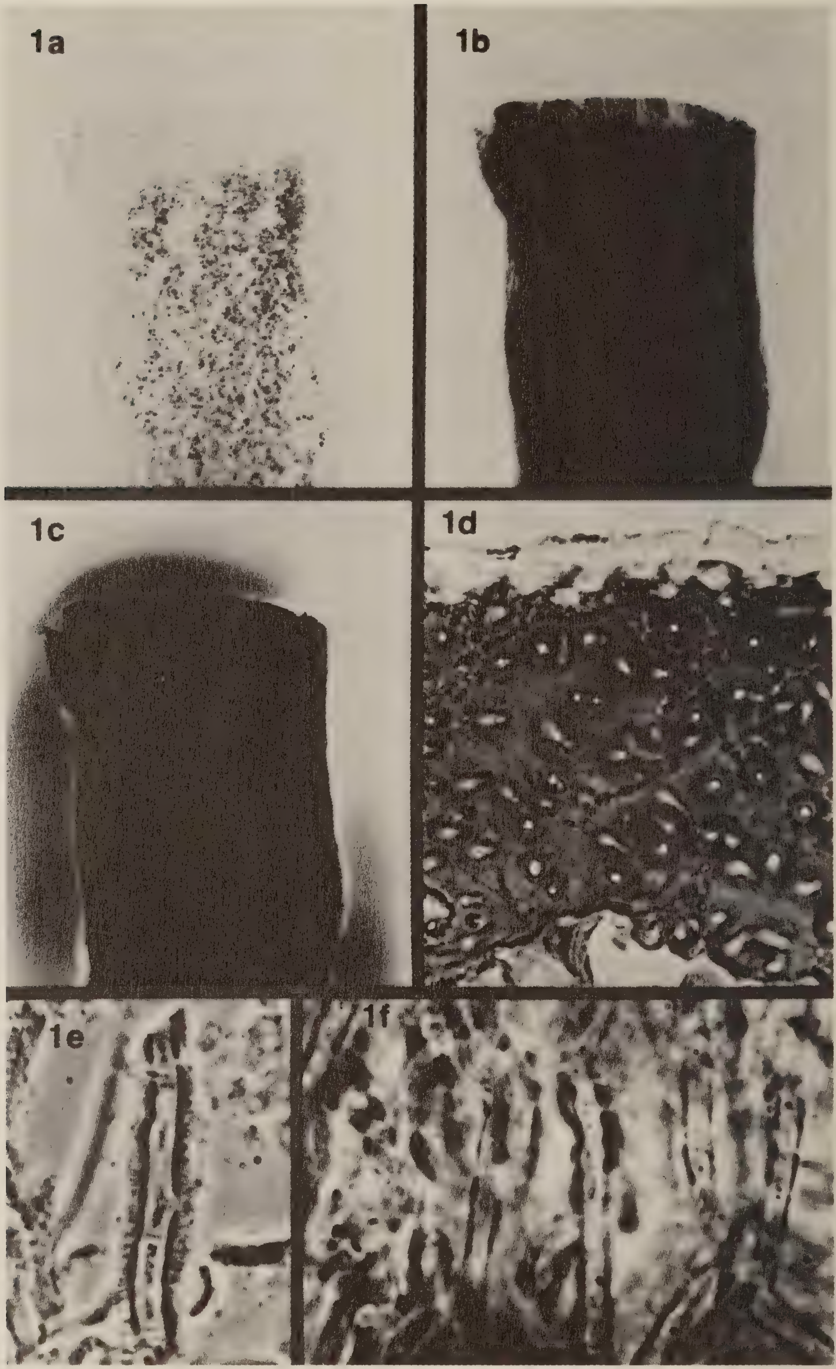
All photographs are of tissue that was bleached to remove naturally occurring pigments. All dense areas of prints represent positive iodine staining. The relative darkness of sections may represent differences in thickness, rather than density of staining. All photographs are brightfield unless specified otherwise. Magnifications given are those of the final reproductions.

Figure 1: 1a) *Oropogon loxensis* in hot 1.5% IKI (h-1.5% IKI test). The lichenan does not form an iodine complex at high temperature, so only staining of the algae is visible. x 80. **1b)** The same slide after cooling briefly. The deep red iodine complex has now formed. **1c)** After standing for a few minutes, the dissolved lichenan forms a fine, dark red precipitate. **1d)** *Alectoria lata* cortex seen in CalKI. Most of the cortex is dark red, with only a thin outer I− zone present. x 800. **1e)** *Cornicularia normoerica* cortical hyphae seen in ZnIKI. A thin layer of lichenan with a true red reaction is appressed to the inner wall of the hypha. Phase contrast, x 1170. **1f)** *Pseudephebe minuscula* from the cortex of a branch tip, seen in ZnIKI. These hyphae have staining similar to those of *C. normoerica.* Phase contrast, x 1170.

Figure 2: 2a) *Cornicularia normoerica* cortex in CalKI. The medullary hyphae, and the matrix material of the cortex are dark red, with a thin I− outer layer of the cortex visible. x 540. **2b)** A section of the same thallus in ZnIKI. Note that the matrix material is I− in this reagent, but a strong red reaction is present in a thin layer appressed to the inner wall of the cortical hyphae, as illustrated in Figure 1e. x 220.

Figure 3: 3a) *Alectoria ochroleuca* cortex in CalKI. The cortex is dark red, with only a thin, eroded, discontinuous outer I− zone. x 700. **3b)** *Bryoria chalybeiformis* cortex in CalKI. A few I− hyphae are seen at the surface, but do not form a continuous layer. x 700. **3c)** *Pseudephebe minuscula* cortex in CalKI. The medulla and inner part of the cortex are red, and a thin, continuous outer I− zone is visible. x 360. **3d)** *Coelocaulon muricatum* cortex in CalKI. A relatively thick, continuous outer I− zone is present in the cortex, with anticlinal red-staining hyphae visible in the lower part of this region. The inner layer of the cortex is uniformly red. x 700. **3e)** *Alectoria nigricans* medullary hyphae in CalKI, showing red-staining ornamentation. x 1700. **3f)** *Alectoria sarmentosa* subsp. *sarmentosa* cortex in CalKI. The section is from an old area of the thallus, and a mixture of red-staining and I− hyphae are seen. Younger areas of the same thallus show uniform red staining (not illustrated). x 660.

Figure 4: 4a) *Oropogon loxensis* cortex in CalKI. The cortex is stained dark red, with a thin, continuous outer I− zone present. x 1170. **4b)** *Coelocaulon steppae* in CalKI. The inner part of the cortex is dark red, and the outer part has a well defined I− zone. x 1170. **4c)** *Oropogon caespitosus* cortical hyphae in CalKI. The secondary wall is seen to consist of concentric layers of I+ red material. x 1170. **4d)** *Bryocaulon pseudosatoanum* medullary hyphae in CalKI, showing red staining ornamentation. x 1170.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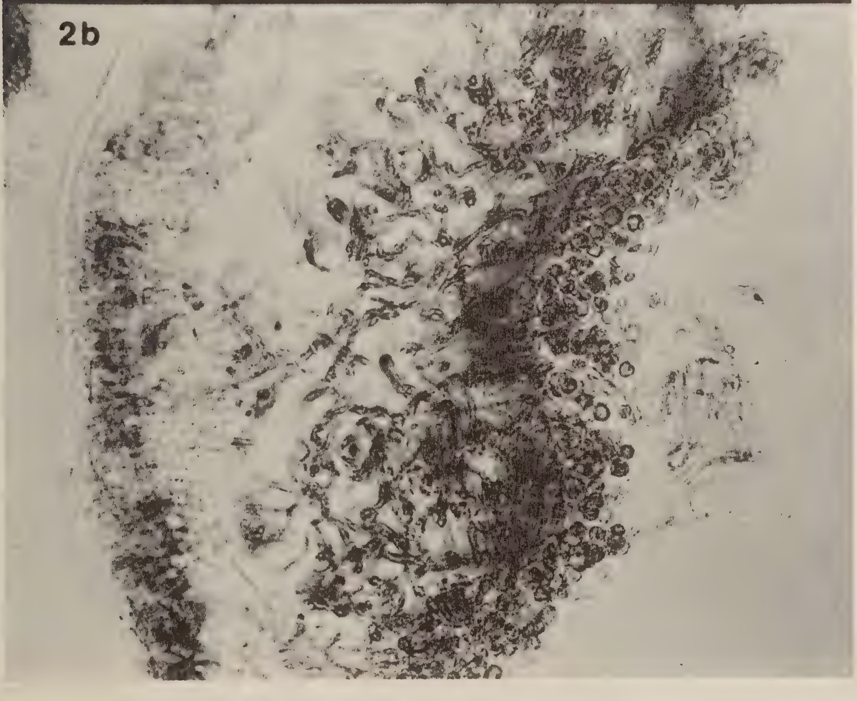
2a



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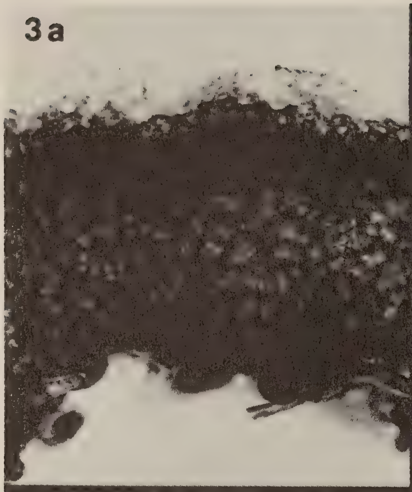

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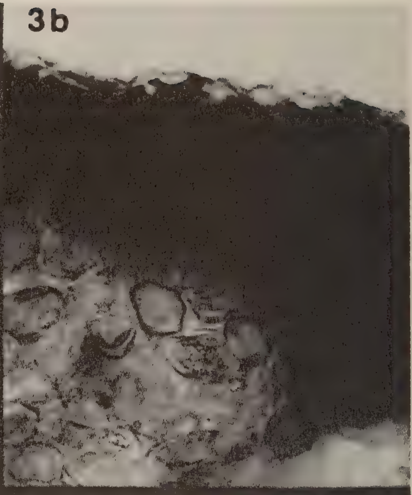

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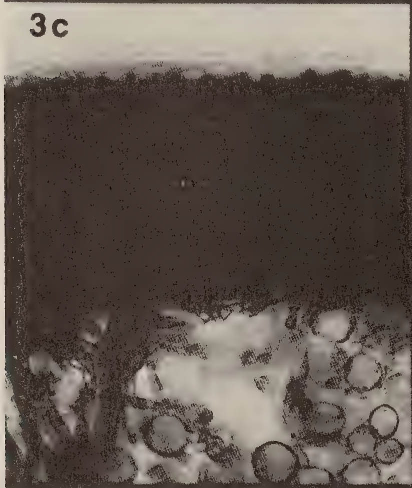

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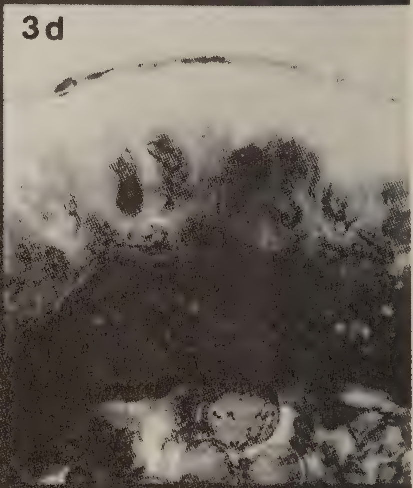

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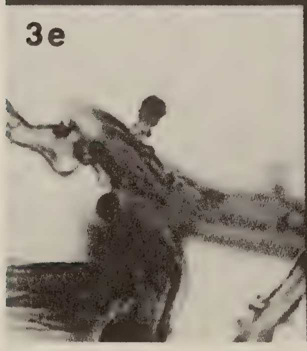

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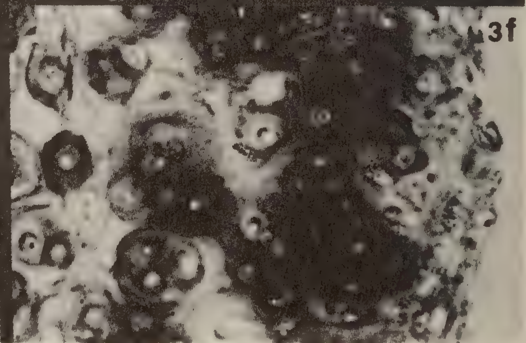

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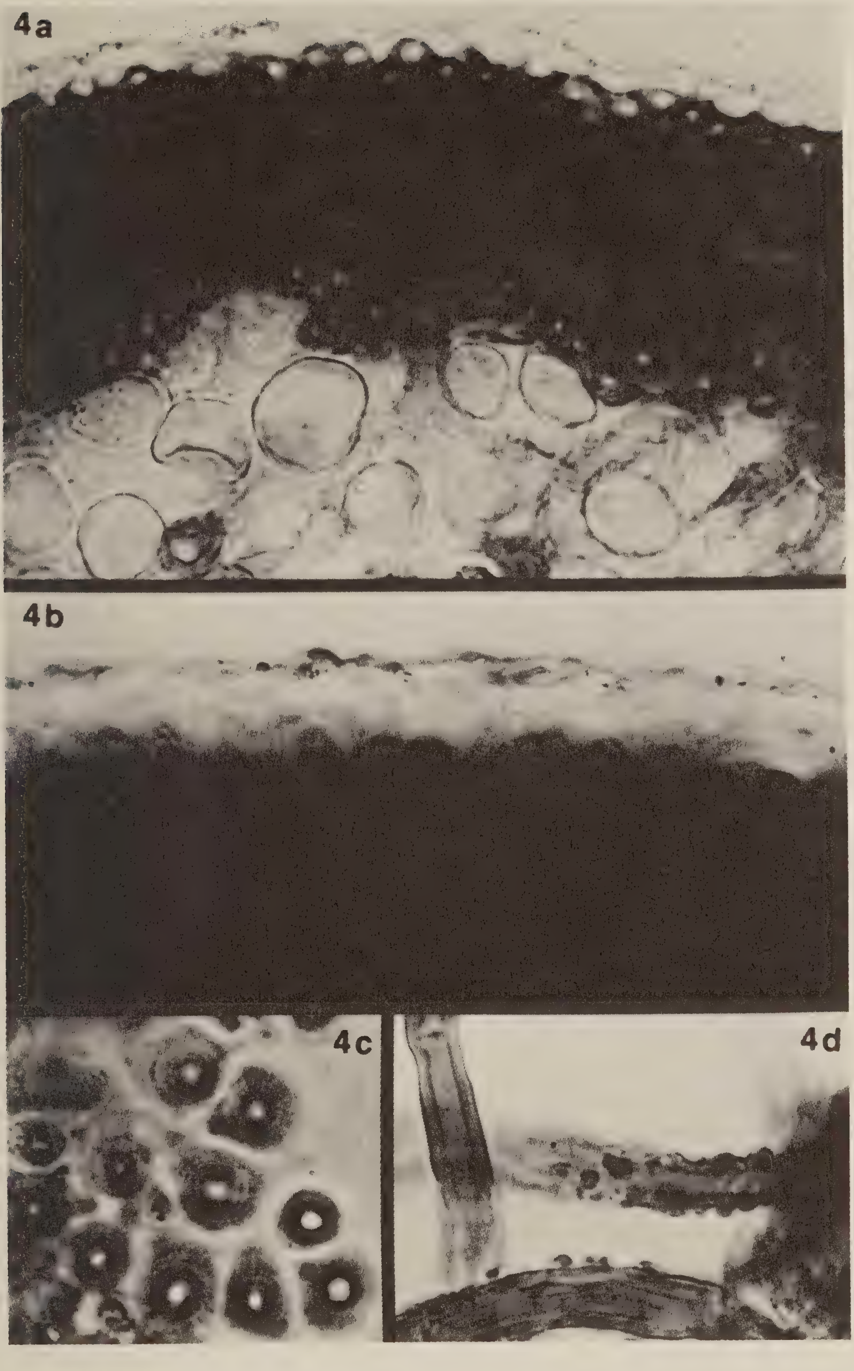
4a
4b
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TABLE I: SUMMARY OF DATA

	DATA										CONCLUSIONS			
	0.15% IKI + BLUE	0.15% IKI + RED	1.5% IKI + RED	MELZER'S REAGENT + RED	CaIKI + RED	ZnIKI + RED	LPIKI + BLUE	20%→0.15% IKI + BLUE	h-1.5% IKI RED PRECIPITATE	HNO_3→1.5% IKI→LPIKI + RED	*CETRARIA*-TYPE LICHENAN	*XANTHOPARMELIA*-TYPE LICHENAN	INTERMEDIATE TYPES OF LICHENAN	ISOLICHENAN
ALECTORIA														
nigricans	+	−	+	−	+	−	+	−	+	−	+	−	−	+
imshaugii	+	−	+	−	+	−	+	−	+	−	+	−	−	+
lata	+	−	+	−	+	−	+	−	+	−	+	−	−	+
mexicana	+	−	+	+	+	−	+	−	+	t	+	−	t	+
ochroleuca	+	−	+	−	+	−	+	−	+	−	+	−	−	+
sarmentosa														
subsp. sarmentosa	+	−	+	−	+	−	+	−	+	−	+	−	−	+
subsp. vexillifera	+	−	+	t	+	t	+	t	+	t	+	−	t	+
vancouverensis	+	−	+	t	+	t	+	t	+	t	+	−	t	+
BRYOCAULON														
divergens	+	−	+	−	+	−	+	−	+	−	+	−	−	+
pseudosatoana	+	−	+	−	+	−	+	−	+	−	+	−	−	+
BRYORIA														
abbreviata	+	−	−	−	−	t	+	−	−	−	−	−	−	+
acanthodes	−	−	+	−	+	−	t	−	+	−	+	−	−	t
bicolor	+	−	+	−	+	−	+	−	+	−	+	−	−	+
capillaris	−	−	+	−	+	−	t	−	+	−	+	−	−	t
cervinula	t	−	+	−	+	−	+	−	+	−	+	−	−	+
chalybeiformis	+	−	+	−	+	−	+	−	+	−	+	−	−	+
fremontii	+	−	+	−	+	−	+	−	+	−	+	−	−	+
friabilis	t	−	+	−	+	−	+	−	+	−	+	−	−	+
furcellata	t	−	+	−	+	−	+	−	+	−	+	−	−	+
fuscescens	+	−	+	−	+	−	+	−	+	−	+	−	−	+
glabra	−	−	+	−	+	−	t	−	+	−	+	−	−	t
implexa	+	−	+	−	+	−	+	−	+	−	+	−	−	+
lanestris	+	−	+	−	+	−	+	−	+	−	+	−	−	+
nadvornikiana	t	−	+	−	+	−	+	−	+	−	+	−	−	+
nitidula	+	−	+	−	+	−	+	−	+	−	+	−	−	+
oregana	+	−	−	−	−	−	+	−	−	−	−	−	−	+
poeltii	−	−	+	−	+	−	?	−	+	−	+	−	−	?
pseudofuscescens	t	−	+	−	+	−	+	−	+	−	+	−	−	+
simplicior	+	−	+	−	+	−	+	−	+	−	+	−	−	+
smithii	−	−	+	−	+	−	+	−	+	−	+	−	−	t
subcana	+	−	+	−	+	−	+	−	+	−	+	−	−	+
subdivergens	+	−	−	−	−	−	+	−	−	−	−	−	−	+
tenuis	−	−	+	−	+	−	t	−	+	−	+	−	−	t
tortuosa	+	−	+	−	+	−	+	−	+	−	+	−	−	+
trichodes	+	−	+	−	+	−	+	−	+	−	+	−	−	+
vrangiana	+	−	+	−	+	t	+	−	+	−	+	−	t	+

TABLE I: CONTINUED

	DATA										CONCLUSIONS			
	0.15% IKI + BLUE	0.15% IKI + RED	1.5% IKI + RED	MELZER'S REAGENT + RED	CaIKI + RED	ZnIKI + RED	LPIKI + BLUE	20%→0.15% IKI + BLUE	h-1.5% IKI RED PRECIPITATE	HNO$_3$→1.5% IKI→LPIKI + RED	*CETRARIA*-TYPE LICHENAN	*XANTHOPARMELIA*-TYPE LICHENAN	INTERMEDIATE TYPES OF LICHENAN	ISOLICHENAN
COELOCAULON														
aculeatum	-	-	+	-	+	-	+	-	+	+	+	-	+	+
epiphorellum	t	-	-	-	-	-	+	-	-	-	-	-	-	+
muricatum	t	-	+	-	+	-	+	-	+	+	+	-	+	+
steppae	-	-	+	-	+	-	?	-	+	+	+	-	+	?
CORNICULARIA														
normoerica	-	-	+	+	+	+	-	+	+	+	+	-	+	-
OROPOGON														
atranorinus	-	-	+	-	+	-	-	-	+	-	+	-	-	-
bicolor	-	-	+	-	+	-	?	-	+	-	+	-	-	?
caespitosus	+	-	+	-	+	-	+	-	+	-	+	-	-	+
diffractaicus	-	-	+	-	+	-	-	-	+	-	+	-	-	-
loxensis	-	-	+	-	+	-	-	-	+	-	+	-	-	-
PSEUDEPHEBE														
minuscula	-	-	+	+	+	+	?	+	+	+	+	-	+	?
pubescens	+	-	+	-	+	+	?	+	+	-	+	-	+	?
RAMALINA														
thrausta	t	-	-	-	-	-	+	-	-	-	-	-	-	+
SULCARIA														
sulcata	?	-	+	-	+	-	t	-	+	-	+	-	-	t

KEY TO TABLE:

"+" indicates a distinct positive reaction with the reagent.

"`t`" indicates that a definite positive reaction was present, but was either very weak, or restricted to a few spots.

"?" indicates that a faint suggestion of color was present, but was so weak that it could not be definitely scored as positive.

"–" indicates that no reaction could be distinguished in the reagent.

DISCUSSION

GENERAL REVIEW OF IODINE POSITIVE MATERIALS

In order to place the iodine reactions seen in lichens and other fungi into perspective, it is useful to review what is known about the iodine-polysaccharide reaction as a general phenomenon, and to survey the range of polysaccharides and other materials that are known to form brightly colored complexes with iodine. Many of these materials are known to occur in lichens, and others may yet be discovered.

STARCH AND ALLIED POLYSACCHARIDES: The blue reaction of starch with iodine was discovered in 1814 by Colon and H. Gaultier de Claubry. Since then, a vast literature on the subject has developed (reviewed by Banks and Greenwood, 1975). Starch has two components: amylose, which is unbranched, and amylopectin, which is highly branched. Both consist of chains of α-(1→4)-linked glucose residues. Amylose stains deep blue-black with iodine, whereas amylopectin stains less intensely, and the color is more lavender or red-purple. Glycogen, a storage product in some fungi as well as animals, is similar to amylopectin, but is even more highly branched, and has shorter terminal chains. It stains reddish with iodine. Much more is known about the amylose-iodine complex than any of the other reactive polysaccharides. In the complexed state, the amylose molecule assumes a tightly spiraled conformation with a hollow center (Teitelbaum et al., 1978; Bluhm and Zugenmaier, 1981). The iodine forms a linear chain in the center of the spiral, with the predominant iodine species varying from I_3^- to I_{15}^-, depending on the concentration of iodide in the solution (Yajima et al., 1987). Experiments with α-(1→4)-linked glucose oligosaccharides have shown that the color of the complex is related to the chain length (average degree of polymerization, or DP). Swanson (1948) showed that as the average chain length is increased, the color shifts from no staining (DP 6 or less), through red to lavender (DP 18), purple, blue-purple, and finally to blue above an average chain length of about 30. The relationship of chain length to color was also studied by Banks et al., 1971; Manners and Stark, 1974; Handa and Yajima, 1980; and Fales, 1980a. In the related branched glucans, glycogen and amylopectin, the color of the complex is related to the average exterior chain length in the same way, so that polysaccharides with short end chains stain weakly and reddish, whereas those with longer end chains will stain more intensely, and the color will shift toward purple or blue (Fales, 1980b). Carroll and Cheung (1962) found that iodine staining was much more sensitive to the polysaccharide chain length than Congo Red.

Techniques using iodine have become one of the standard ways of characterizing starches (Banks and Greenwood, 1975; Takeda et al., 1983) and glycogen (Craig et al., 1988). Starch is present in *Trebouxia*, and gives a positive test with all of the iodine reagents used in this study.

CELLULOSE: Cellulose is found in the cell walls of some fungi, most notably Oomycetes (Aronson and Lin, 1978; Bertke and Aronson, 1985, etc.), as well as higher plants and some algae. It is composed of long unbranched chains of β-(1→4)-linked glucose residues. The structure of cellulose has been reviewed by Marchessault and Sundararajan (1983). It has been known since 1830 that cellulose can react with iodine under certain conditions to form a blue colored complex (for reviews of the early literature on this subject, see Zimmerman, 1893; Post and Laudermilk, 1942; Rowe, 1943; Puchtler and Sweat, 1966; Alterman, 1976). Numerous tests and reagents utilizing iodine were introduced to detect the presence of cellulose, or to assess its degree of crystallinity or origin (Graff, 1935; Shinouda et al., 1978). Cellulose from most sources does not react directly with dilute solutions of IKI. Native cellulose is in a crystalline state, and must be disrupted in some way before the iodine complex can form. Most of the tests, developed for the paper or textile industries, involved the use of concentrated salts, usually calcium chloride, zinc chloride, magnesium chloride, aluminum chloride, lithium chloride, or magnesium sulfate. The reagents were either combined directly with IKI, or the material being tested was transferred from IKI to the reagent for observation (Nelson, 1970). Potassium iodide itself can act as a swelling agent for cellulose (Doppert, 1967). A similar action on the *Xanthoparmelia* form of lichenan may be the cause of the positive reaction seen with the 20%→0.15% IKI test. Treatment with strong alkali, such as 50% KOH, can also alter cellulose and make it more reactive to iodine.

Among mycologists, tests using zinc chloride-IKI and sulfuric acid-IKI reagents have been most popular (see Frey, 1950 and Hopkins, 1929 for reviews). The specificity of these tests has often been questioned (Frey, 1950; Roelofsen and Hoette, 1951). Jewell (1974), however, showed that properly performed iodine tests correlate well with results from X-ray diffraction for the detection of cellulose in *Ceratocystis* and *Europhium*. The distribution of cellulose in these genera correlated with both morphological features, and categories established earlier by Spencer and Gorin (1971), based on the proton magnetic resonance spectra of mannans, a separate class of polysaccharides found in these fungi.

Cellulose is present in the cell walls of the *Trebouxia* phycobiont in all of the lichens in this study. The walls of the algae stain dark purplish in ZnIKI, reddish in Melzer's reagent and CaIKI, and are blue after the 20%→0.15% IKI test.

MANNANS AND XYLANS: Hemicelluloses, non-glucan heteropolysaccharides found in the cell walls of plants, are also sometimes iodine positive. The properties of these polysaccharides in calcium chloride-iodine solution were described in a series of papers by Gaillard and co-workers (1961, 1965, 1966, 1969, and 1971). This series of papers constitutes perhaps the most comprehensive attempt to explain the iodine-polysaccharide interaction. Numerous polysaccharides from many sources were studied, including the glucans amylopectin, lichenan and isolichenan. Interestingly, Gaillard and Bailey (1966) reported that lichenan, along with the structurally related cereal β-glucans, formed a colored precipitate with iodine (the color was not specified), but found isolichenan to be negative, at least in the sense that it did not give a precipitate, under the conditions used. The CaIKI reagent I have used in my research is not the best reagent for viewing isolichenan reactions, but an I+ bluish reaction can be seen, for example in *Bryoria abbreviata*, when the reaction is moderately strong, and lichenan is absent and not obscuring the reaction. Note that Gaillard tested the polysaccharides in a dissolved state, whereas isolichenan is probably in a gel state in the tests as performed here.

Gaillard found that many hemicelluloses, including rhodymenan (a seaweed xylan), salep glucomannan, and ivory nut mannan, as well as lichenan, were precipitated from the calcium chloride solution and formed a colored complex upon the addition of iodine. It was reported that the polysaccharides that precipitated tended to be those with long unbranched or relatively lightly branched chains, and having (1→4)-linkages, whereas those that did not precipitate were either highly branched, or lacked consecutive (1→4)-linkages. Gaillard and Bailey (1966) attribute the fact that lichenan gave an I+ precipitate, whereas isolichenan did not, to a higher proportion of consecutive (1→4)-linkages in lichenan. All of the I+ polysaccharides they reported contained either glucose, mannose or xylose in the backbone of the chain. As with the botanical amyloids (see below), some contain short one or two unit side chains containing other sugars, including arabinose and galactose.

Gaillard's technique has been extended by Morak and Thompson (1965). These workers found that some of the polysaccharides that precipitate with the formation of a colored iodine complex in calcium chloride solution were not precipitated from zinc chloride solution by iodine. They also found that bromine could precipitate some, but not all, of the I+ polysaccharides from calcium chloride solution. The precipitate was bright orange. This work raises the interesting possibility that bromine could be used to distinguish between I+ lichen polysaccharides.

Gaillard's method has since been used by many workers to fractionate plant polysaccharides, and many I+ xylan fractions have been isolated using this method. This procedure, or a modification of it, might be an excellent method for the extraction and purification of lichenan.

CHITIN AND CHITOSAN: Chitin is a polysaccharide which is widely distributed among invertebrates as well as fungi. In fungi, it is a component of the primary cell wall. The distribution, properties, and literature on chitin have been reviewed by Muzzarelli (1977). Chitin is composed predominantly of β-(1→4) linked N-acetyl-D-glucosamine residues forming a long unbranched chain, and may be regarded as a derivative of cellulose (Foster and Webber, 1960). Chitin does not form a colored complex with iodine in its native form. The partially de-N-acetylated derivative, chitosan, however, does give a brownish color in IKI, and a red-violet color in iodine-sulfuric acid (Foster and Webber, 1960). This is the basis for the well known van Wisselingh test for chitin, which was widely used during the first half of this century to establish the distribution of chitin among the fungi. The test involves heating tissue in 60% aqueous KOH to 160 °C for several hours. Most polysaccharides are completely dissolved by this treatment. An I+ violet residue (chitosan) was considered positive for the presence of chitin in the original sample. The specificity of the reaction has often been questioned (Roelofsen and Hoette, 1951). It should also be noted that chitosan itself occurs as a natural component of the hyphal walls of many mucoralean fungi (Bartnicki-Garcia 1968), accounting for the reddish brown color of their walls in some iodine reagents. The nature of the chitosan-iodine complex has been studied by Shigeno et al. (1980). They conclude that the color reaction is caused by a charge-transfer complex between iodine and the amino groups of chitosan, rather than being an inclusion compound, such as the amylose-iodine complex.

AGAR: Agar is a complex mixture of structurally related polysaccharides believed to have a backbone consisting of alternating (1→4)-linked 3,6-anhydro-α-L-galactose and (1→3)-linked β-D-galactose residues (Duckworth and Yaphe, 1971). Agarose, the least substituted and most neutral fraction of agar, forms a purplish red complex with IKI. Ng Ying Kin and Yaphe (1972) note that agarose only forms a complex with iodine in the gel state, and not in true solution. Nisizawa (1982) states that agarose, like amylose, has a coiled cylindrical structure, and that polyiodide (iodine-iodide) ions occupy the central cavity of the polysaccharide in the complexed state.

AMYLOID: The term "amyloid", used as a noun, was once used for the I+ blue material, now known to be modified cellulose, that results from the treatment of higher plant tissues with sulfuric acid (Puchtler and Sweat, 1966). In modern botanical usage, the term is applied to a group of structurally related polysaccharides found in the seeds or other tissues of higher plants from several different families (Kooiman, 1960). These polysaccharides have a main chain of β-(1→4)-linked glucose residues, with short side chains containing xylose, galactose, and fructose (Courtois, 1976; Kato et al., 1977, 1981; Hsu and Reeves, 1967; Gould et al., 1971; Siddiqui and Wood, 1971, 1977; and many more). The iodine reactive part of these polysaccharides would appear to be the cellulose-like backbone of the molecule. The short side chains apparently do not interfere with the iodine complex. Gould et al. (1971) have suggested that the blue complex is not an inclusion compound, as seen with amylose, but instead that iodine, and possibly iodide ions, lie in the interstices between aggregated xyloglucan chains.

A very different kind of material is called "amyloid" in the medical literature. Abnormal deposits of this material can occur in many tissues as the result of disease processes. In 1853 Virchow (see reviews by Alterman, 1976, and Puchtler and Sweat, 1966) discovered that this material stained bluish with iodine-sulfuric acid, and compared the reaction to the "amyloid" reaction of cellulose seen with the same reagent in plant tissues. It is now known that the deposits that result from amyloidosis are mostly proteinaceous in composition, and that it is the protein fraction that is responsible for the iodine staining (Cooper, 1974).

LICHEN SUBSTANCES AND OTHER NON-POLYSACCHARIDE MATERIALS: Iodine can also form brightly colored complexes with a large number of other non-polysaccharide organic chemicals, including saponarin and narceine (Barger and Fields, 1906), pyrones (Barger and Starling, 1915), benzamide (Robin, 1964), poly(vinyl acetate) and poly(vinyl alcohol) (Morishima et al., 1978) and nylon (Shigeno et al., 1980). Blackwell et al. (1985) have attributed the red reaction of some Basidiomycetes in Melzer's reagent to the presence of quaternary ammonium compounds (QACs). The lichenologist should be aware that not all iodine color reactions are caused by polysaccharides, since a number of lichen substances, most notably stictic acid, can also form bright red or blue complexes with iodine under certain conditions. No lichen substance reactions were encountered while studying the species under consideration in this paper, but the reactions are frequently seen in other groups within the Parmeliaceae s.l. These reactions will be discussed in more detail in subsequent publications.

THE CHEMISTRY OF LICHENAN AND ISOLICHENAN

LICHENAN: "Lichen-starch", a mixture of lichenan and isolichenan, was first isolated from *Cetraria islandica* in 1813 by Berzelius (Smith, 1921). The name "lichenin" was introduced by Guérin-Varry (1834), who also noted the blue color of this mixture with iodine. In 1838, Mulder recognized that two distinct components were involved (Smith, 1921). The major component was said to color yellow with iodine, and the minor component (isolichenan), which Mulder believed to be true starch, was colored blue. Lichenan has since been subjected to considerable chemical investigation. Carter and Record (1939) estimated the degree of polymerization of several lichenan derivatives. The estimates varied from 52 to 410, with the best agreement around 80. Meyer et al. (1948) reported the chain length to be about 160. The chain length of cellulose, by contrast, is several thousands. Lichenan is soluble in hot water, but not in cold water. Chanda et al. (1951) determined that lichenan was a linear glucan consisting of β-(1→4) and β-(1→3) linkages in the ratio 3:7. Peat et al. (1957) presented evidence suggesting that lichenan has a regular repeating structure consisting of β-cellotriose units linked by (1→3) bonds. Perlin and Suzuki (1962), using enzymatic degradation, reported that lichenan has some sequences of three consecutive β-(1→4)-linked glucose residues in addition to the β-cellotriose units. The crystal structure of lichenan was studied by Marchessault and Deslandes (1980) and Tvaroska et al. (1983). These workers reported that lichenan has a three-fold helical structure with two associated chains running in opposite directions. The structure is described as being very similar to hydrated regenerated cellulose. The presence of (1→3) linkages in lichenan was said to give the molecule more flexibility than native crystalline cellulose. In this context, it is interesting to note that lichenan is the predominant component of the tough but flexible support tissue (the cortex) of the lichens under consideration here. In *Usnea* and related genera, lichenan is found in the central cord, rather than the more brittle cortex.

The specific rotation of lichenan is $[\alpha]_D^{22}$ +18° (Fukuoka et al., 1968). The ^{13}C-n.m.r. spectroscopy of lichenan has been reported by Gagnaire and coworkers (1975, 1976), Yokota et al. (1979), Dais and Perlin (1982) and Gorin and Iacomini (1984). Sakai et al. (1982) succeeded in synthesizing a pentasaccharide which includes the repeating unit of lichenan, and Takeo and Suzuki (1986) synthesized similar tri- and tetra-saccharides.

Much of the recent interest in lichenan has centered on its possible antitumor activity. In recent years, Japanese workers have carried out an extensive survey of fungal polysaccharides, including those from lichens, to detect host-mediated antitumor activity on implanted tumors in mice. Studies including lichenan were made by Fukuoka et al (1968), and

Nishikawa and coworkers (1974, 1979, 1981). Lichenan was found to be among the most effective polysaccharides tested (Nishikawa et al., 1974), producing remission in 100% of the mice. Watanabe et al. (1986) found that the effect of lichenan may be more direct than other polysaccharides, since destruction of the tumor appeared to begin immediately, rather than after a two week delay as usually seen with the host-mediated effect.

Lichenan is also of interest outside the lichenological community as a substrate for testing the specificity of enzymes. In one such study Williams (1983) stained the lichenan-containing substrate with iodine to detect areas of lichenase activity (no staining where the lichenan had been degraded). This is one of the very few reports in the literature of the I+ red reaction of lichenan. Lichenases have been reported from numerous organisms, including both microorganisms and higher plants.

Lichenan is very similar in structure to glucans found in the seeds or other tissues of monocots, including economically important cereal grains such as oats and barley. Similar polysaccharides are known from a few dicots as well (Hensel and Franz, 1988). At least some of these polysaccharides are I+ (Gaillard and Bailey, 1966). This class of polysaccharides is believed to be more variable in structure than true lichenan, both between sources and within the same source. Flemming and Manners (1966a) compared the fine structure of lichenan with that of barley glucan, and found that the latter, unlike lichenan, had blocks of consecutive (1→3) linkages. Bathgate et al. (1974) found that the arrangement of linkages could differ depending on the source and method of isolation. Kato and Nevins (1986) found the β-D-glucan from *Zea mays* shoots to contain small areas with two or more consecutive (1→3) linkages, as well as areas with alternating (1→3) and (1→4) linkages, and areas with more than four consecutive (1→4) linkages. The enzymatic analysis of this class of polysaccharides, including lichenan, has been reviewed by McCleary and Matheson (1986).

Wood and coworkers (1982, 1983) studied the interaction of cereal grain β-glucans with Congo Red and Calcofluor. Evans et al. (1984) studied the interaction of the blue fluorochrome, Sirofluor, with many polysaccharides. They found apparently contradictory behavior among the mixed linkage β-glucans, with barley glucan showing almost no fluorescence, whereas true lichenan showing moderately strong fluorescence. Jørgensen (1988) and Jørgensen and Aastrup (1988) describe a method for the quantification of cereal grain β-glucan complexed with Calcofluor. These studies used *Cetraria islandica* lichenan as a standard.

Lichenan has been reported from many lichens in conventional chemical studies. Of particular relevance to the present study, Takeda et al. (1972) reported that lichenan was isolated from *Alectoria sarmentosa* and *Alectoria sulcata* (= *Sulcaria sulcata*). Other species recently reported to contain lichenan are *Usnea rubescens* (Nishikawa et al., 1974), and *Cetraria richardsonii* (= *Masonhalea richardsonii*) (Nishikawa et al., 1969). Both of these species test strongly positive for *Cetraria*-type lichenan with the iodine tests. Most significantly, Shibata (1973b) reported that lichenan occurs in *Parmelia conspersa* (=*Xanthoparmelia conspersa*). This is apparently the only species yet studied chemically that has typical *Xanthoparmelia*-type lichenan reactions with iodine reagents. The polysaccharide was apparently not fully purified and characterized in this study, so no inference can be drawn concerning the differences between lichenan from this species and *Cetraria*-type lichenan. Schlarmann (1987) reported that "lichenan or a lichenan-like" glucan was found in the outer-wall layer of the medullary hyphae of *Hypogymnia physodes*. This material combined with both Calcofluor White and analine blue (=Sirofluor) to produce very intense fluorescence. In my studies of this species, the medullary hyphae give a strong lichenan reaction with characteristics similar to the *Cetraria* form. The cortex is negative. Interestingly, Schlarmann reported that the medullary hyphae were stained (color not specified) by zinc-chlor-iodide. They are not stained by the ZnIKI reagent used in the present study. This apparent discrepancy is undoubtedly due to differences in the composition of the reagents. I found that by decreasing the concentration of zinc chloride, and increasing the iodine concentration slightly, red staining resulted. Clearly, solutions containing zinc chloride and iodine can give very different results depending on the concentration of the components.

It has been reported that lichenan can be precipitated from calcium chloride solution by iodine, with the formation of a colored complex (Gaillard and Bailey, 1966). This was discussed earlier in the "mannans and xylans" section of this report.

In the older chemical literature, there are several references to "lichenan" occurring outside of the Parmeliaceae s.l.. Dhar et al. (1959), for example, cites lichenan from *Xanthoria parietina*, and Mittal et al. (1952) report lichenan from *Ramalina sinensis*. My iodine tests are negative for lichenan in these species, and all other *Ramalina* and *Xanthoria* species tested. These workers appear to be using the term "lichenan" for any hot-water extractable glucan. No investigation of the linkage types was reported. These, and other older reports of lichenan, should be viewed with skepticism.

Takeda et al. (1972) isolated a polysaccharide fraction from *Evernia prunastri* having β-(1→3) and β-(1→4) linkages in the ratio 3:1 and a chain length of about 60 glucose residues. *Evernia prunastri* does not give a positive test for lichenan with iodine reagents.

ISOLICHENAN: Isolichenan, like lichenan, is a linear (unbranched) homoglucan, first isolated from *Cetraria islandica*. The linkages in isolichenan, however, are a mixture of α-(1→3) and α-(1→4) in the ratio reported to be 11:9 (Peat et al., 1961), or 3:2 (Chanda et al., 1957). Flemming and Manners (1966b) found the ratio to be 56.5:43.5, and 57:43 in two separate procedures. The distribution of linkages was found to be somewhat irregular, with both types occurring in groups of two or more in at least some areas (Peat et al., 1961) McCleary and Matheson (1986) state that isolichenan has mostly groups of one or two α-(1→3) bonds surrounded by α-(1→4) bonds. The chain length of isolichenan was estimated at 42-44 glucose residues by Chanda et al. (1951). Perhaps because of this relatively short chain length, isolichenan, at least after it has been extracted from the lichen thallus, is soluble in cold water. Note, however, that I have never seen any tendency for isolichenan to dissolve out from sections of lichen tissue, except as the result of treatment with KOH. The ^{13}C-n.m.r. spectrum of isolichenan was reported by Yokota et al. (1979) and Gorin and Iacomini (1984).

Typical isolichenan has been reported from several species belonging to the Parmeliaceae s.l., including *Cetrelia cetrarioides* (Shibata et al., 1973b), and *Masonhalea richardsonii* (Nishikawa et al., 1969), which are positive in 0.15% LPIKI in my tests. Among the species covered in this paper, only *Alectoria sarmentosa* and *Sulcaria sulcata* have been studied by conventional chemical means. Both were found to contain isolichenan (Takeda et al., 1972), in agreement with the iodine data presented here.

The positive lilac or lavender coloration given by isolichenan with iodine has been known for many years. The blue staining element of "lichen-starch" was first isolated by Mulder in 1838 (Smith, 1921), who believed that this material was true starch. The name "isolichenin" was given to this substance by Beilstein in 1881 (Smith, 1921). The nature of the iodine-isolichenan complex has never been studied. The coloration is much less intense than in glucans, such as amylose, that have only α-(1→4)-linkages. Acroscyphan, a related glucan from *Acroscyphus sphaerophoroides* (Yokota et al., 1979) gives a much stronger purplish reaction. This polysaccharide has α-(1→3) and α-(1→4) linkages in the ratio 2:3. This higher proportion of α-(1→4) linkages probably accounts for the more intense reaction (see the discussion under "mannans and xylans", above). Several other polysaccharides with mixed α-(1→3) and α-(1→4) linkages have been reported. Takeda et al. (1970) identified a polysaccharide fraction (PC-3) from *Flavoparmelia caperata* having alternating α-(1→3) and α-(1→4) linkages. This polysaccharide was reported to be I−, in agreement with my own tests on *F. caperata*. Evernin, from *Evernia prunastri,* has α-(1→3) and α-(1→4) linkages in the proportion of 4:1 (Stefanovich, 1969). Takeda et al. (1972) isolated two similar fractions from *E. prunastri*, one having linkages as reported for evernin, the other having α-(1→3) and α-(1→4) linkages in the proportion 3:2, almost exactly that of isolichenan. This latter fraction, designated EP-6, has a

DP of 160 and a specific rotation of $[\alpha]_D^{17}$ +164°, as compared to +255° for isolichenan. No iodine reaction was reported for this isolate, and my own observations on this species show no positive iodine reaction. Gorin and Iacomini (1984) isolated a glucan from *Ramalina usnea* having α-(1→3) and α-(1→4) linkages with the ratio 31:19. This isolate was said to have a blue color corresponding to that of amylose, although the ^{13}C-n.m.r. spectrum did not show signals specific for amylose. My observations on this species indicate that a light but definite reaction typical of isolichenan is present throughout the cortex, clearly belonging to the mycobiont tissue.

IODINE REACTIONS ASSOCIATED WITH ASCI AND ASCOGENOUS HYPHAE: The iodine reactions seen in the apices of asci, on their surfaces, or on the surface of ascogenous hyphae are very familiar, and are well established as taxonomic characters in mycology and lichenology. Considerable information has existed in the literature for many years concerning the odd behavior of these reactions in various iodine reagents, but many workers remain unaware of, or unconcerned with, the facts necessary to properly perform and interpret these reactions. This subject has recently been reviewed in detail by Baral (1987), as well as by Eriksson (1966), Kohn and Korf (1975) and Nannfeldt (1976). The Baral paper, which may have been overlooked by some lichenologists, is an excellent review of the hymenial iodine reactions of lichens, as well as non-lichenized fungi. Lichenologists using iodine would be well advised to familiarize themselves with its findings. I have observed the iodine staining properties of asci in numerous lichen genera, in all of the major taxonomic groups. My findings are, with a few exceptions, in good agreement with those of Baral. As has apparently been the case with many other lichenologists and mycologists, I discovered the quirks of these reactions independently, and only later became aware of their long history in the literature. Stated in my own words, the situation is as follows:

The iodine positive reactions associated with asci in lichens and non-lichenized ascomycetes are probably caused by a single family of related polysaccharides which have a wide but continuous spectrum of staining characteristics. At one extreme are forms which are I+ blue in IKI solutions of all concentrations tested (up to 20% in my research), as well as in other reagents. At the other extreme are forms which are I− at very low iodine concentration, but which become reddish as the iodine concentration is raised, with the transition point always well below 0.15% IKI concentration. These forms will be I− in Melzer's reagent and in LPIKI. The majority of lichens have forms with intermediate properties: at low iodine concentration staining is bluish, but at some higher concentration staining becomes red or orange. Baral calls the point at which the staining changes the "critical point". The degree of staining of these forms in Melzer's reagent and LPIKI will vary, such that the higher the critical point of the material, the stronger the blue reaction will be in Melzer's and LPIKI. Forms with a low critical point may be completely I− in Melzer's or LPIKI, even though blue is seen in dilute IKI solutions. The iodine staining properties of the red or intermediate forms are greatly altered by pretreatment with KOH. After treatment, these forms will react much like the extreme blue form: they remain blue at high IKI concentration, and stain blue in Melzer's and LPIKI. Within a specimen, the critical point is usually not uniform, and even within a single ascus, substructures can be seen to react differently. Frequently the sheath has a lower critical point than the tholus, and sometimes different zones are visible within the sheath. Often, brownish shades will be seen, interpreted here as a mixture of blue, red, and yellow (I−) staining materials. At high IKI concentration, the blue coloration will look grey or black, due to the filtering effect of the dense yellow solution.

Baral introduced the term "hemiamyloidy" to describe reactions that are I+ red in 1.0% IKI, but I+ blue after pretreatment with KOH. This definition includes both forms that, without pretreatment, never stain blue in dilute IKI solutions, and those which are blue at low concentration, but become red at higher concentration. Those that remain blue in 1% IKI without pretreatment are called "euamyloid". Baral did not observe hemiamyloid reactions with a critical point higher than 1% in IKI. I would add that some lichens do have reactive materials with a critical point above 1% in IKI, and that these forms are part of the same continuum of reaction types. In *Pertusaria* and *Caloplaca* species, for example, it is common to see a loss or reduction of blue staining in at least parts of the ascus in more concentrated solutions. At high iodine concentration, it is difficult to tell if the loss of blue is actually replaced with reddish staining, since the reagent itself is so darkly colored. In any case, the terms "hemiamyloid" and "euamyloid" should not be interpreted as implying the presence of two fundamentally different types of reactive material, since Baral also believes that all of the hymenial reactions belong to a single class of polysaccharides. The most important point of disagreement between my interpretation and that of Baral involves the identity of this `I+` material. Baral indicates a belief that the material is isolichenan. The assumption that isolichenan is the `I+` blue material of asci seems to be fairly common among lichenologists. Lamb (1947) attributed the blue staining to isolichenan, and red staining to glycogen. Galun et al. (1976) erroneously state that "lichenan and isolichenan are common substances in fruiting bodies (the hymenium and hypothecium) of many lichen species, but are apparently rather rare in their thalli". Baral (1987) cites other examples.

On the surface, the staining patterns of hymenial elements may seem to closely resemble that seen in the thallus tissue of lichens such as *Cetraria islandica*, where blue staining is seen at low IKI concentration (due to isolichenan) and reddish staining is seen at high concentration (which I have attributed to lichenan). Baral studied *C. islandica*, but did not report the reddish coloration of lichenan, presumably because he used a 1% IKI solution, which is very near the threshold of staining. Coloration of lichenan is much more intense in 1.5% IKI. One not familiar with the staining properties of lichenan might attribute this reddish color to a different staining phase of the isolichenan. The two situations, however, can be differentiated in a number of ways:

1. Relatively weak blue hymenial reactions, i.e., those with low critical points, are negative or nearly so in LPIKI solutions. Weak isolichenan-type reactions, on the other hand, are seen to best advantage in this solution.
2. The isolichenan-iodine complex is more stable when heated in LPIKI than is the hymenial-type reaction. When reactive specimens are brought to boiling in LPIKI, the reaction (if initially moderately strong) remains visible if the slide is immediately viewed microscopically. The blue hymenial reactions are lost when heated, and do not return until cooled somewhat. An `I+` blue precipitate may form upon cooling. No precipitate is formed with isolichenan.
3. Isolichenan-type reactions are always weakened by KOH pretreatment (apparently by extraction), whereas the hymenial reactions become more strongly blue after KOH.
4. Lichenan is not converted to a form that stains blue in IKI by KOH pretreatment. Lichenan is gelatinized by KOH, whereas the hymenial polysaccharide is not. The threshold of staining is much higher for lichenan than the hymenial polysaccharide, both before and after KOH treatment. Pretreatment with KOH does seem to slightly lower the threshold of staining in *Xanthoparmelia*-type lichenan, but the initial staining is pale purplish red, and soon becomes strongly red, never showing the pure, dark blue color of the hymenial reactions.
5. Isolichenan-like reactions within the Parmeliaceae s.l. are never as intense as the reactions seen in hymenia, and the color is more lilac or lavender in shade.
6. Isolichenan-like reactions are almost always restricted to thallus tissue or sterile elements of ascocarps. The reaction type characteristic of asci is usually seen, as pointed out by Baral, only on the dikaryotic hyphae (ascogenous hyphae and asci). There are important exceptions to the latter, however, as discussed below.

Baral (1987) bases the assertion that isolichenan is the I+ blue material of asci on the report of its occurrence in *Xanthoria parietina* in Culberson (1969). Baral examined *X. parietina* and found no I+ blue reaction outside the hymenium. The original source of this report is Dhar et al. (1959). These workers obtained a fraction of polysaccharide from *Xanthoria parietina* that showed bluish coloration in iodine and which, upon hydrolysis, "gave only D-glucose". Linkages were not studied, and the identification of this extract as "isolichenan" was probably based on the I+ blue coloration itself. My own study of this species indicates that isolichenan may well be present, but that it is present in the thallus, and is clearly distinguishable from the I+ blue material in the hymenium. Study of several specimens (see "materials") has shown that an I+ lavender material that has iodine staining properties similar to isolichenan, is present in the lower cortex and rhizinae, and sometimes in the upper cortex as well. The reaction remains visible in hot LPIKI, whereas hymenial tissue from the same section looses coloration when hot. The coloration of the two materials is also quite distinctly different when seen side by side. It is not clear whether the report by Dhar et al. (1959) was based on the isolichenan-like material in the thallus, the I+ blue material in the hymenium, or a mixture of the two. No conclusion as to the nature of the hymenial material can be drawn from this study.

Perhaps a better indication that the reactive polysaccharide may be a glucan comes from Mittal and Seshadri (1954). These workers extracted "isolichenan" from *Roccella montagnei* thalli. As with most other members of the Arthoniales s.l. (i.e., including the Opegraphaceae), the *Roccella* spp. that I have studied (*R. canariensis* and *R. fuciformis*; *R. montagnei* was not seen) have an iodine reaction in the vegetative hyphae which is indistinguishable from the hemiamyloid-type reactions normally seen only in asci and ascogenous hyphae in other groups. Mittal and Seshadri extracted an I+ blue polysaccharide fraction from this lichen which gave only glucose after acid hydrolysis. No linkage studies were made, nor other data given except that the sample "has all the properties of isolichenin given in the literature". I cannot accept the finding that the predominant blue-reacting material of this lichen is identical to isolichenan, but the possibility that isolichenan is also present can not be excluded. *Roccella* spp. would seem to be excellent candidates for macrochemical study, since they are abundant and easily collected in mass in some localities, and contain an interesting polysaccharide that has never been properly characterized chemically.

Since the I+ material associated with asci seems to belong to a single family of polysaccharides, it is useful to give it a name. A name for it, in fact, already exists in the literature. Crié (1879) called it "amylomycine". Since this name is perfectly appropriate, and there seems to be no established alternative, I suggest that it should be reintroduced, with a minor alteration in spelling - "amylomycan" - to accommodate modern chemical nomenclature.

McCracken and Dodd (1971) and Dodd and McCracken (1972) seem to imply that they have identified "the" amyloid material of fungi as a form of amylose. The actual species they studied, however, all belonged to the basidiomycete genera *Russula, Clavicorona*, and *Lentinellus*. I am unaware of any reports of hemiamyloid iodine reactions being associated with any form of amylose. Even if amylomycan should prove to be a glucan with some chemical affinities with amylose or isolichenan, the consistent differences in staining properties, remarkable in being preserved in so many diverse groups of ascomycetes, must surely reflect structural and biological differences of sufficient importance that they should be considered as distinct chemical classes.

There are a few exceptions to the generalization made above, that isolichenan occurs only on sterile thallus hyphae, and amylomycan only on asci and ascogenous hyphae. As discussed above, typical amylomycan-like reactions are seen in thalli of most of the genera of the Arthoniales, including *Opegrapha* and allied groups. These reactions have occasionally been noted in the literature (ex., Poelt and Döbbler, 1979). I believe that this unusual feature, along with similarities in ascus structure, provide strong evidence that the Opegraphaceae and Roccellaceae should be retained within the Arthoniales. Another exception to the generalization

TABLE II: SUMMARY OF IODINE REACTION TYPES

REAGENT→ MATERIAL:	KOH prt.[1]	0.15% IKI	1.5% IKI	0.15% LPIKI	CalKI	ZnIKI	Melz.[9]	20%→ 0.15% IKI	N→1.5%[10] IKI→ LPIKI
ISOLICHENAN	no	bluish[2]	bluish	bluish	bluish	bluish	bluish	bluish	bluish
	yes	bluish[3]	bluish	bluish	bluish	bluish	bluish	bluish	bluish
LICHENAN	no	neg.	red	neg.	red	neg.[12]	orange	neg.	neg.
Cetr. type	yes	neg.	red						
LICHENAN	no	neg.	red	neg.	red	bluish	red	blue	bluish
Xanth. type	yes	neg.	red						
AMYLOMYCAN[4]	no	red	red	neg.	red	neg.	neg.		
extr. red form[5]	yes	blue	blue	blue	blue	blue	blue		
AMYLOMYCAN	no	var.[11]	red	var.[8]	red	var.[8]	var.[8]		
intermed. form[6]	yes	blue	blue	blue	blue	blue	blue		
AMYLOMYCAN	no	blue	blue	blue	blue	blue	blue		
extr. blue form[7]	yes	blue	blue	blue	blue	blue	blue		

KEY TO TABLE:

1. With (yes) or without (no) pretreatment for one minute in 10% KOH.
2. Isolichenan color is variable, depending on source and concentration, usually more lavender or lilac than the pure blue of amylomycan.
3. Isolichenan staining is weakened by KOH pretreatment.
4. "Amylomycan" is the name used here for the I+ material associated with asci.
5. The extreme red-staining form, i.e., the "rr" type of hemiamyloid reaction of Baral (1987).
6. The intermediate form, i.e., the "br" type of hemiamyloid reaction of Baral (1987). Note that this type reaction has a spectrum of forms, and that the iodine concentration (the "critical point") at which staining shifts from blue to red varies.
7. The extreme blue-staining form, i.e., the "bb" or "euamyloid" type reaction of Baral (1987).
8. Variable, negative or blue. Red reactions have not been observed in these reagents.
9. Melzer's reagent.
10. Specimen pretreated in 70% nitric acid for one minute, rinsed in 1.5% IKI, and transfered to 0.4% LPIKI.
11. Variable, blue or red, depending on the critical point of the material.
12. False red reactions are possible. True red reactions are seen with some intermediate forms.

NOTE: Blank spaces indicate tests that were not routinely performed, and insufficient data is available for generalizations to be made. "Neg." (negative) indicates no coloration or yellowish coloration.

is seen in a few species belonging to the Graphidaceae, which have a bluish reaction in the hymenium, apparently produced by the paraphyses, which is very close to isolichenan in its characteristics, and clearly not of the usual type associated with asci in other groups. The intense purplish reaction of the spores often seen in the Graphidaceae usually does not have the properties described for amylomycan, but in a few cases, for example *Graphina mendax*, senescent spores do show an amylomycan-like reaction. The immature, and mature spores in good condition, are I− in this species.

TAXONOMIC IMPLICATION OF LICHENAN AND ISOLICHENAN DISTRIBUTION

As outlined above, many polysaccharides are known to form colored complexes with iodine. These include, in addition to lichenan and isolichenan, amylose, amylopectin, glycogen, cellulose, agarose, and chitosan, as well as certain xylans, mannans, and mixed-sugar polysaccharides such as botanical amyloid. Clearly, many different sugars may form I+ polysaccharides. What these polysaccharides have in common is a predominance of either α-(1→4) or β-(1→4) linkages in at least part of the molecule. Isolichenan seems to be a partial exception to this rule, since it has a slight preponderance of α-(1→3) linkages, probably accounting for the relatively weak intensity of its iodine reaction. The physical nature of the complex has been studied most thoroughly for amylose, a linear α-(1→4)-linked glucan which is the major component of starch. The iodine complex consists of a tube-like, spirally arranged amylose molecule with iodine and iodide molecules situated in the center of the tube. The color of the complex is directly related to the length of the amylose molecule, and thus the length of the polyiodide chain that can occupy the center of the tube. Short molecules form reddish complexes. As the length of the amylose molecule is increased, the complex becomes more bluish in color. It has been suggested that the mechanism of complex formation may not be the same in all cases (see the discussions of amyloid and chitin above).

In view of the large variety of materials that react with iodine, it might seem foolhardy to attempt to attribute these reactions to specific substances. I have found, however, that the reactions seen in lichens frequently have varying and distinctive properties with different reagents, and can further be characterized by the effects of other factors, such as pretreatments with strong acids or bases, solubility in hot water, or the stability of the complex when heated. Iodine complex formation with polysaccharides is non-specific in that many different sugar types may be involved. The reaction is quite sensitive, however, to changes in the stereochemistry of the polysaccharide. This may account for the very different results that are seen with iodine reagents of varying composition. Commonly used reagents contain chloral hydrate, lactic acid, sulfuric acid, or high concentrations of zinc chloride, calcium chloride, potassium iodide or iodine itself, all of which may apparently alter the configuration of the polysaccharide so as to facilitate, or prevent, the formation of the iodine complex. Pretreatments, particularly with KOH or concentrated nitric acid, also appear to alter the native configuration of the polysaccharide, and thus facilitate iodine complex formation.

Iodine reactions are very common in the thallus tissue of many groups of lichens, and many of these reactions can be clearly distinguished from each other. I have surveyed most of the major taxonomic groups of lichens, and lichenan-like reactions have not been found to occur outside the Parmeliaceae s.l. (i.e., including the Usneaceae, Hypogymniaceae, Alectoriaceae, and Anziaceae). I+ red reactions are seen in thallus and ascocarp tissues of many other groups of lichens, but lack the distinctive set of characteristics shown by lichenan, as outlined in the "methods" portion of this paper. The reports of lichenan from genera outside the Parmeliaceae s.l. appear to result from an overly broad definition of "lichenan" to include any hot water extractable glucan from lichens.

When lichenan is detected by iodine tests, it is almost always present in high concentration. Isolichenan-like iodine reactions, however, are often very weak. The reactions seen in numerous members of the Parmeliaceae, presumably from polysaccharides related to the isolichenan of *Cetraria islandica*, are not very distinctive. They are a bluish shade in all of the iodine reagents, and lack well differentiated properties which can be used to distinguish them from most of the I+ blue materials seen in other groups of lichens. Perhaps this is because these reactions are all caused by isolichenan-like polysaccharides. Since the polysaccharides of most of the lichens with these reactions have not been studied, however, the possibility that other sugars or linkages are present cannot be excluded. Isolichenan can, however, be clearly distinguished from the I+ blue polysaccharides that occur in most hymenial tissues.

Widely distributed polysaccharides such as amylose, amylopectin, and glycogen are known to vary considerably from source to source in such features as degree of polymerization (i.e., molecular weight), branching frequency, and branch length. The properties of the iodine complexes of these polysaccharides have been found to be of great value in characterizing these variations, and have become a standard part of their descriptions. Similarly, the lichenan- and isolichenan-like staining patterns described above, which are seen in numerous species throughout the Parmeliaceae, probably represent similar groups of polysaccharides related by both structure and phylogeny. With lichenan, not only the presence or absence of the reaction, but the variations of the reaction when present, appear to be extremely useful taxonomic characters.

LICHENAN AND ISOLICHENAN IN *ALECTORIA* AND ALLIED GENERA: Isolichenan was found in the cortex or medullary tissue of nearly all of the species included in this study (see table 1). All of the species of *Alectoria* and *Bryoria* were positive, except possibly *B. poeltii*. An I+ blue reaction was reported for some species by Bystrek (1969) but positive reactions were not seen by Brodo and Hawksworth (1977). This discrepancy is apparently due to the weak nature of many of the reactions, and to the fact that Brodo and Hawksworth used Melzer's reagent, or a diluted form of it. Pale isolichenan reactions are not nearly as distinct in this reagent as they are in 0.15% LPIKI. Bleaching of the tissue before observation also greatly improves the visibility of these faint reactions.

Lichenan reactions were very strong in all of the species that were positive. In the few species that were scored negative, the reaction was completely absent. Lichenan appeared to be the dominant structural polysaccharide in the cortex of all of the positive species, and was usually abundant in the medulla as well. All of the positive species in the present study contained lichenan which had staining characteristics similar to lichenan from *Cetraria islandica*. In addition, several of the genera have species containing lichenan which is similar to the *Xanthoparmelia* form of lichenan. This type is usually present only in trace amounts. In *Cornicularia normoerica*, however, there are numerous hyphae throughout the cortex which have staining characteristics similar to *Xanthoparmelia*-type lichenan. Even here, however, most of the lichenan, comprising the bulk of the matrix between cortical hyphae, behaves like *Cetraria*-type lichenan. The unusual lichenan in *Cornicularia* and *Pseudephebe* is not identical to the *Xanthoparmelia* type since it stains red, not blue, in ZnIKI, and is similarly reddish instead of bluish with the nitric acid→1.5%IKI→0.4% LPIKI test. It is interesting to note that lichenans similar to the *Xanthoparmelia* type are best developed in the species which occupy ecological niches closest to that of *Xanthoparmelia*. This may be a case of ecologically induced convergence.

The distribution of lichenan seen in alectorioid genera have several important implications for classification and identification. The similarity in the type and distribution of lichenan between *Alectoria* and *Bryoria* species is another important feature which these genera have in common. Both lichenan and isolichenan were seen in nearly all species of both genera. Further, the polysaccharides were seen in similar locations in both genera, with lichenan found throughout the cortex, and isolichenan strongest in the inner part of the cortex. The distribution and type of lichenan was similar in *Oropogon* and *Sulcaria*. The exclusion of

Alectoria, Sulcaria, and Oropogon from the Parmeliaceae (Eriksson and Hawksworth, 1988), based on spore characters is, in my opinion, unjustified.

The species which lack lichenan, however, appear to be good candidates for reclassification. The three species of *Bryoria* which were negative for lichenan all belong to section *Subdivergentes* (Mot.) Brodo and Hawksworth. The unusual cortical anatomy of these species is not seen elsewhere in the genus, and it was said that the section "appears to occupy a rather isolated position within *Bryoria*" (Brodo and Hawksworth, 1977). The only other lichenan negative species found in the genera studied here is *Coelocaulon epiphorellum*. Similarly, Kärnefelt (1986) states that *C. epiphorellum* "has a somewhat isolated position in *Coelocaulon*, and placing it there is based on structural and chemical characters entirely, since both apothecia and pycnidia are unknown". Further, he points out that *C. epiphorellum* is the only member of the genus confined to the Southern Hemisphere, and differs from other members of the genus in several morphological characteristics.

The presence or absence of lichenan is an easily determined and distinctive characteristic which should be incorporated into keys dealing with these groups. The character will, for example, immediately separate *B. oregana* from *B. fremontii*, with which it is occasionally confused. Likewise, the distribution of the ZnIKI positive hyphae easily separate *Cornicularia* from *Pseudephebe*. The taxonomic usefulness of isolichenan within the genera under study would seem to be more limited. The weak and somewhat variable nature of the isolichenan reactions seen in many species makes this character unsuitable for routine identification. It is quite possible that some of the species scored as isolichenan negative will be shown to be positive with the study of more specimens. There are certainly distinct differences in intensity of the reactions between species in the specimens studied, but I have not carried out large scale sampling within a species to determine how consistent the isolichenan staining characteristics are between specimens or between geographical regions. What little information I have suggests that considerable variability may exist, even between thalli in a single collection. I would therefore not place much importance on this character when considering taxonomic placement.

LICHENAN, ISOLICHENAN, AND POLYSACCHARIDE CHEMOTAXONOMY: Whereas secondary products are taxonomically useful mostly at the species or genus level in lichens, polysaccharide content is often diagnostic for larger phylogentic units (Shibata 1973a,b). Polysaccharides have a much more fundamental role in the biochemistry of the fungi, and tend to be conservative features in their evolution. Some polysaccharides are taxonomically significant at the highest levels of classification. The presence of chitin, chitosan, or cellulose in the cell wall, for example, is a feature which helps to define the classes of fungi (Bartnicki-Garcia, 1968). Other polysaccharides, such as amylomycan, are virtually constant within orders or families. Within the lichens, pustulan is characteristic of the Umbilicariaceae, and glycopeptides are important cell wall components in the Lobariaceae (Shibata, 1973b). Takahashi et al., (1981) have shown that polysaccharides may be important for the taxonomy of stereocaulaceous lichens.

As will be more evident when this series of papers is completed, lichenan content seems to be an excellent taxonomic character which is useful at the genus or subfamily level. Even the distinctions between the major variants of lichenan are of taxonomic significance. The widespread occurrence of lichenan within the Parmeliaceae s.l. would seem to indicate that it is a primitive characteristic of the group, and that the absence of lichenan is a derivative character within the family. Lichenan is the major structural polysaccharide of the secondary wall in most of the species in which it occurs, and shifts in its occurrence or structure appear to have been relatively few during the evolution of the mycobionts. Lichenan occurs in at least some of the genera in most of the families (Alectoriaceae, Parmeliaceae s. str., Usneaceae, Anziaceae, and Hypogymniaceae) that have been split from the Parmeliaceae s.l. Lichenan-like iodine reactions have not been found in the Ramalinaceae. I have not found iodine reactions characteristic of lichenan outside the Parmeliaceae s.l. This is another strong indication that the Parmeliaceae s.l. is a natural group which should be recognized at some level. I believe that the most appropriate level for the group is the family, and that the narrower groupings should be accepted at levels between the family and genus. I also suspect that, when lichenan content is taken into account, additional groupings of intermediate rank will be recognized.

At the time this study was started (mid 1970s), many of the genera of the Parmeliaceae s.l., as they were then constituted, were heterogenous in lichenan content. Since then many new genera have been erected, and most have been more uniform with respect to the occurrence of lichenan. Iodine reactions for lichenan, based either on Common (1981), or subsequent personal communication, were cited in the original publication of five new genera by M.E. Hale. *Flavopunctelia* (Hale, 1984) is lichenan positive, whereas both *Punctelia* and *Parmelia* s. str. lack lichenan. *Arctoparmelia* (Hale, 1986a) has typical *Cetraria*-type lichenan, and was segregated from *Xanthoparmelia* partially on this basis. The reactions in "I(CH)", i.e. iodine-chloral hydrate, cited in Hale (1984) refer to Melzer's reagent. *Karoowia* (Hale, 1989b) has typical *Xanthoparmelia*-type lichenan. *Psiloparmelia* (Hale, 1989a) was segregated from *Xanthoparmelia*, in part because of the negative lichenan reactions of its species. Also, the negative lichenan reaction of *Flavoparmelia* species (Hale, 1986b) was noted. In addition to these, several other groups that were identified as being atypical within their genus for lichenan content by Imshaug (1981) have recently been given new taxonomic status. *Omphalodium hottentottum*, a species that was aberrant in having *Xanthoparmelia*-type lichenan, was transferred to the new genus *Xanthomaculina (Hale, 1985)*, which is uniformly positive for this type lichenan. *Parmotrema cetratum, P. reticulatum, P. simulans* and *P. subisidiosum* all have lichenan reactions that are intermediate between the *Cetraria*- and *Xanthoparmelia*-types (most other species of *Parmotrema* have the *Cetraria*-type). These species have been incorporated into the genus *Rimelia* (Hale and Fletcher, 1990). *Parmelina pilosa*, a lichenan positive species in an otherwise negative genus, was transferred to *Canomaculina (Elix and Hale, 1987)*, a genus which is uniform for *Cetraria*-type lichenan. Note that the interpretation of Krog and Swinscow (1981, 1983), that *C. pilosa* and *C. consors* should be placed in *Parmotrema*, is also consistent with my data for lichenan content and type. *Parmeliopsis aleurites* and *P. placorodia*, which have *Cetraria*-type lichenan, were transferred to the new genus *Imshaugia* by Meyer (1985). The species remaining in *Parmeliopsis* are lichenan negative. *Pseudoparmelia annexa, P. molybdiza, P. tortula*, and *P. xanthomelaena* have *Xanthoparmelia*-type lichenan, as well as *Xanthoparmelia*-like morphology. These species were transferred to *Paraparmelia* (Elix et al., 1986), a genus which also contains a few lichenan negative species. Two species with typical *Cetraria*-type lichenan (*Pseudoparmelia inornata* and *P. caribaea*) and two species with lichenan showing intermediate characteristics (*P. martinicana* and *P. raunkiaeri*) were transferred to *Canoparmelia* (Elix et al., 1986), where they remain atypical, since most of the other species are lichenan negative.

These taxonomic changes have reduced the level of lichenan heterogeneity considerably. Based on the species studied to date, within the Parmeliaceae s.l., 34 genera with a total of 197 species are uniformly positive for *Cetraria*-type lichenan; 5 genera with 18 species are uniform for *Xanthoparmelia*-type lichenan; and 25 genera with 123 species are uniformly lichenan negative. Heterogeneity with respect to lichenan content was seen in ten relatively large genera, but only 23 of the total of 270 species studied in these genera varied from the predominant type for presence or absence of lichenan.

Within a specimen, lichenan is almost always either abundant and easily detected, or completely undetectable with iodine reactions. Lichenan content is a very useful practical character for identification, and should take a prominent place in keys dealing with parmeliaceous lichens. There are very few examples of species in which lichenan is present in only a small amount. These include the *Hypotrachyna sinuosa* group, in which lichenan is seen only in the rhizinae (other species in the genus are completely negative), and

Paraparmelia mongaensis, in which the lichenan reaction is restricted to areas of the cortices, and seems to be variable in extent between specimens. The most extreme example, the only of its type known, is *Omphalodium pisacomensis*, in which only the faintest trace of a lichenan-like reaction can be seen in some specimens, and none at all in others (Nash et al., 1990). These few examples may represent true intermediates, species or groups of species in the process of loosing lichenan. In other cases of heterogeneity, such as those in *Bryoria* and *Coelocaulon* discussed above, the discordant elements probably represent well separated lines of evolution which should be placed elsewhere or elevated to a higher taxonomic rank. I do not believe in rigid rules for the interpretation of taxonomic characters, such that a given character is always considered diagnostic at a given taxonomic level. Taxonomic characters should always be judged in the context of the group in question, and in combination with other characters. In most cases, however, I believe lichenan positive and negative species should be accepted within the same genus only in the absence of correlating characters, or where a strong case can be made for the aberrant elements being transitional species. The status of these aberrant species or groups should become clear when more is known of their complete polysaccharide content. What replaces lichenan in the negative species? Are there biogenically related molecules that are iodine negative, but should be considered part of the lichenan family of polysaccharides? And what are the structural differences which account for the different staining properties seen in positive species?

Isolichenan is not nearly as constant at the genus level as lichenan. While there may be strong tendencies within a group for it to be present (as in *Alectoria* and *Bryoria*) or absent (*Xanthoparmelia*), many genera are very heterogenous for its presence, or at least its detectability with iodine. As has been emphasized in this paper, isolichenan-like iodine reactions are often extremely weak. This may represent either a low concentration of isolichenan, or perhaps the presence of forms which have a lower affinity for iodine. It seems quite possible that the family of isolichenan-like polysaccharides may include homologous forms which lack detectable iodine staining. If this is so, then isolichenan, in this broader sense, might be a more important character than it seems at present at higher levels of classification. Macrochemical studies, or other methods of microchemical analysis, will be necessary to establish if this is so.

Iodine positive polysaccharides have a special importance in the chemotaxonomy of fungi, including lichens, because they provide immediately accessible characters that do not require expensive equipment or laborious procedures to observe. They also have the special advantage that their distribution between tissues, and even to some extent their position within the hyphae, can be directly observed with the light microscope. Their presence helps to elucidate structural as well as chemical characteristics. This is certainly the case with lichenan. Yet most polysaccharides are iodine negative. Lichen fungi contain a complex mixture of polysaccharides within their cell walls. There is no reason to think that the iodine negative polysaccharides are not potentially as useful taxonomically as the positive ones have proven to be. I believe that there is an urgent need to develop techniques which will allow for the study of these iodine negative cell wall constituents with greater ease and economy than can be achieved with conventional macrochemical analysis.

The great value of microchemical techniques such as iodine staining is that a relatively large amount of data can be gathered in a reasonable amount of time, and with little expense. This series of papers will report the presence or absence of lichenan and isolichenan in over six hundred species of lichens. Neither funding, nor lichen material itself, is available to accomplish this broad a survey using conventional macrochemical techniques. Biochemical research usually centers on a relatively few representative organisms which are studied in great depth. No one doubts the value of this approach. Yet, the taxonomist needs information which, even if less detailed, encompass all of the organisms under study.

Other techniques have been developed which might lend themselves to the type of broad survey necessary for the taxonomist. FITC-conjugated lectins (Schlarmann, 1987) seem to have much promise. Galun et al. (1976) also used FITC-conjugated lectins, as well as autoradiography (using labeled sugars as cell wall precursors) to study cell wall structure in a few lichens and non-lichenized fungi. Well known stains such as Congo Red, chlorazol black, toluidine blue, resorcin blue, and others have at least partial specificity with regard to polysaccharide staining. The Thiére reaction (PATAg) used in transmission electron microscopy (TEM) stains polysaccharides with (1→2), (1→4), and (1→6) linkages, but not those with only (1→3) linkages. It is essentially the TEM counterpart of the PAS staining procedure for light microscopy (Dring, 1954). The PATAg technique has been used for the ultrastructural localization of polysaccharides in lichen cell walls by Malachowski et al. (1979), Baker et al. (1980), Boissiére (1982) and others, particularly in studies of ascus structure. Much more specific is a modification of this method (ETAg) developed by Joseleau and Ruel (1985), which utilizes specific enzymes rather than periodate to produce the free aldehyde groups necessary for staining. Boissiére (1982) used "chemical dissection" to study the cell walls of *Lasallia pustulata* and *Peltigera canina*. This technique combines sequential treatments with chemical or enzymatic reagents with TEM examination to locate the area within the cell wall affected by the reagent. The most powerful technique presently available may be ultrastructural localization using colloidal gold. In this technique, extremely fine gold particles are conjugated with lectins, enzymes, or antibodies of known specificity, and allowed to react with ultrathin sections of tissue. A deposit of gold particles is seen with TEM in areas containing the appropriate substrate. This type of study is technically demanding, and the chemicals involved are expensive, but the economies of scale would seem to apply. A well planned survey involving many species seems practical. For examples of this type of analysis of fungal cell walls, see Bendayan (1984), Benhamou (1988), Chamberland et al. (1985), and Bonfante-Fasolo (1986).

Microchemical techniques, particularly those using iodine, are sometimes viewed as a poor substitute for conventional chemical analysis. Such was the case with the iodine tests used to detect chitin and cellulose in fungal walls. It is sometimes overlooked, however, that even though errors were made, it was by the use of these simple tests that the distributions of these materials in fungi was first discovered, and the usefulness of these polysaccharides in fungal taxonomy revealed. The results from these tests stimulated and focused later research with more powerful techniques. I believe this will be the case with the iodine techniques I have developed. The distribution of lichenan, as determined with these tests, is of course an hypothesis that can be tested with conventional chemistry. The test results predict which species will have lichenan, and where variations in lichenan structure occur. The results of the iodine tests provide a detailed guide showing which species should be studied to gain the most information. Microchemical and macrochemical techniques should be viewed as being complementary, most powerful when used together. These results should also be of interest to those studying the medical applications of lichenan, since unusual forms of the substance are revealed, and many new sources are indicated.

The iodine positive polysaccharides should be seen as only the "tip of the iceberg" in cell wall chemotaxonomy. I predict that cell wall chemistry will prove to be at least as important at the genus level and above, as secondary products have been at the species level. Lichens are an ancient group of organisms. Their cell walls are more complex than those of simpler, more ephemeral fungi. They undoubtedly contain many novel, as yet undiscovered polysaccharides. Hopefully, the potential medical and industrial uses of polysaccharides will help to stimulate interest, and funding, for this neglected area of research.

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MYCOTAXON

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CONTRIBUTION TO THE STUDY OF THE *MYXOMYCETES* IN SPAIN. IV.

by

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ABSTRACT

37 taxa of *Myxomycetes* are reported from several spanish localities. The following are new to peninsular Spain: *Badhamia capsulifera* (Bull.) Berk., *Badhamia nitens* Berk., *Badhamia obovata* var. *dictyospora* (Rost.) Lister, and *Hemitrichia minor* var. *pardina Minakata*. The remaining taxa have been cited only a few times or they complete the catalogue of *Myxomycetes* of Extremadura.

INTRODUCTION

Recently ILLANA & al. (1990) have realized an essay of a catalogue of the spanish *Myxomycetes* (including the Balearic and Canary Islands) in which 296 taxa have been compiled. In the present publication records new to Spain are described; the catalogue of the autonomous community of Extremadura, comprising the provinces of Badajoz and Cáceres, both with 25 and 83 taxa respectively, is completed. Cáceres becomes, this way, one of the provinces with the highest number of *Myxomycete records.*

A brief macro- and microscopic description, as well as some taxonomical comments are given for the species which are new to the spanish mycological catalogue and for those which have been cited only a few times.

The collector (leg.) is named when the material has been found by others than the authors of this paper.

The material is kept in the herbarium of the Department of Plant Biology (Botany) of the University of Alcalá de Henares (H.AH).

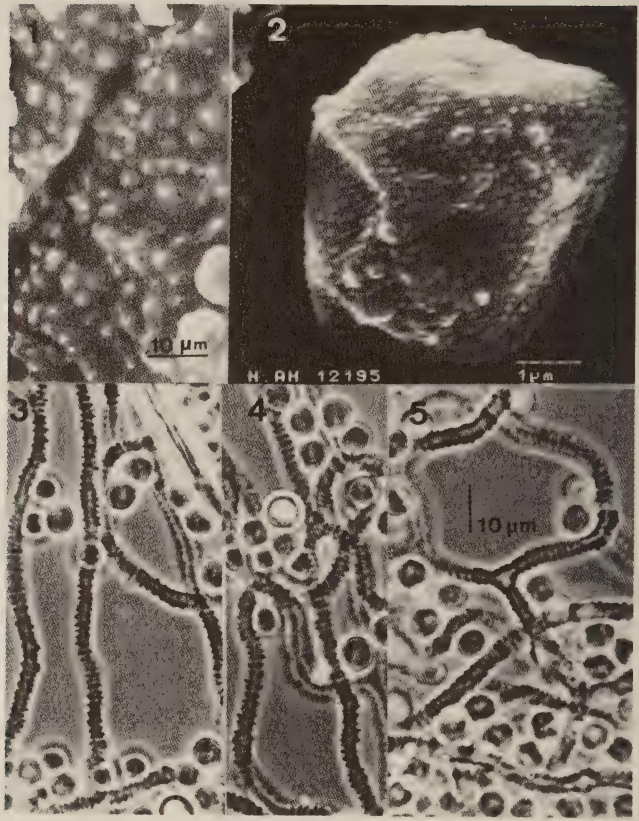
CATALOGUE OF SPECIES, LISTED ALPHABETICALLY

Arcyria insignis Kalchbr. & Cooke

Sporocysts pale-reddish to pink, 0,5-2 mm high, growing in groups of 10-20 units. It has only been cited from northern Spain and from the Canary Islands.

CACERES: On stem of *Nicotiana* sp., Tejeda de Tietar, 14-XII-1989, H.AH 12456, 12457 and 12022. Idem, 19-I-1990, H.AH 12025, 12026 and 12200. Idem, 27-IV-1990, H.AH 12354 and 12455.

Arcyria minuta Buchet
= Arcyria carnea (G. Lister) G. Lister
= Arcyria gulielmae Nann.-Brem.

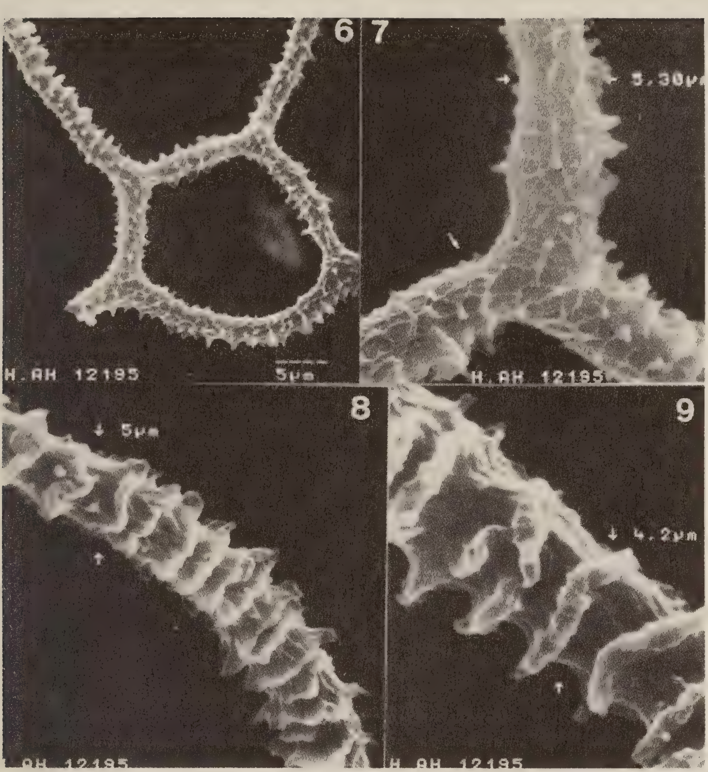


Figs. 1-5. *Arcyria minuta*: calyculus, spores and capillitium. (H.AH 12.195)

This species is characterized by its heterogeneous capillitium ornamentation, being annulated showing crests, half-rings and more or less pronounced reticulations; the calyculus has non-reticulated papillas; the spores are warted (Figs. 1-9).

In our collections the smaller specimens present a macroscopy close to *A. cinerea* with a greyish colour, without reddish tints which only appear when the capillitium expands.

In taxonomical matters we refer to NEUBERT & NANNENGA-BREMEKAMP (1979).



Figs. 6-9. *Arcyria minuta*: capillitium (H.AH 12.195)

This taxon is only known from Barcelona, Murcia and the Canary Islands.

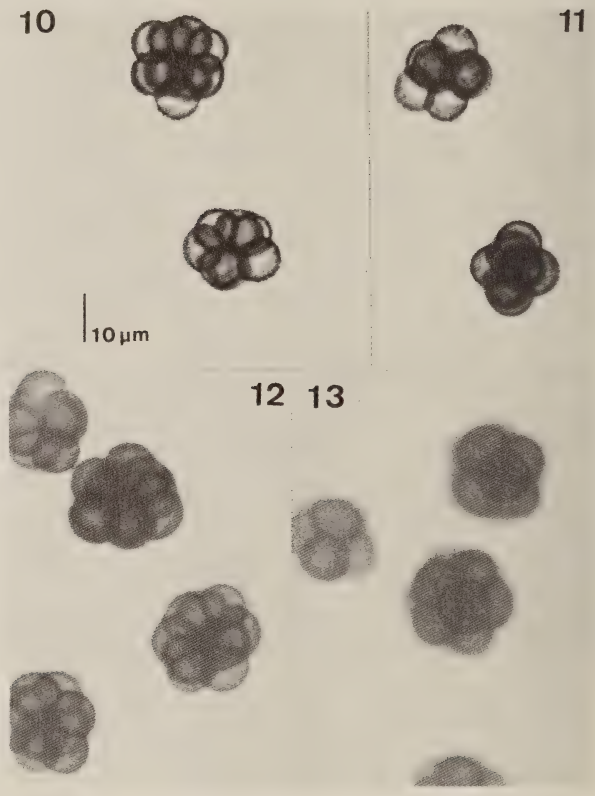
CACERES: On wood of *Pinus pinaster*, mountain pass of los Castaños, 19-I-1990, H.AH 12195 and 12197. Idem, on wood of *Eucalyptus camaldulensis*, H.AH 12196. Idem, 28-XI-1988, H.AH 11393.

Badhamia capsulifera (Bull.) Berk.

It forms small colonies with sporocysts very close together, peridium greyish-iridiscent and stalk flexuous whitish straw-coloured. Capillitium formed by whitish to yellowish filaments which form a characteristic net. Spores in clusters of 8-20 spores, subglobose to pyriform, purple-brown, with big spines on the outside of the cluster, 12-13 x 12-14 µm (Figs. 10-11).

This is a new record for the Iberian peninsula though it was already known before in Spain from the Canary Islands (CHAMPION & BELTRAN, 1980).

MADRID: On wood of *Cistus ladanifer*, Puebla de la Sierra, 4-I-1990, leg. A. Acha, H.AH 12347.



Figs. 10-11. *Badhamia capsulifera*: spores (H.AH 12.347)
Figs. 12-13. *B. nitens*: spores (H.AH 12.211)

Badhamia nitens Berk.

This species is easy to identify because of the yellowish tints of its sporocysts which are 0,5-1 mm in diam., and because of its spores in clusters of 6-14 spores, measuring 11-13 x 11-12 µm. (Figs. 12-13)

Badhamia bispora (WHITNEY, 1978) is close to *B. nitens* because of the yellowish colour of peridium and capillitium; however, the spores of *B. bispora* are in clusters of two units, which is unique in the genus *Badhamia*. Recently, McHUGH (1986) has analyzed the connections between the spores in the clusters in *B. nitens*.

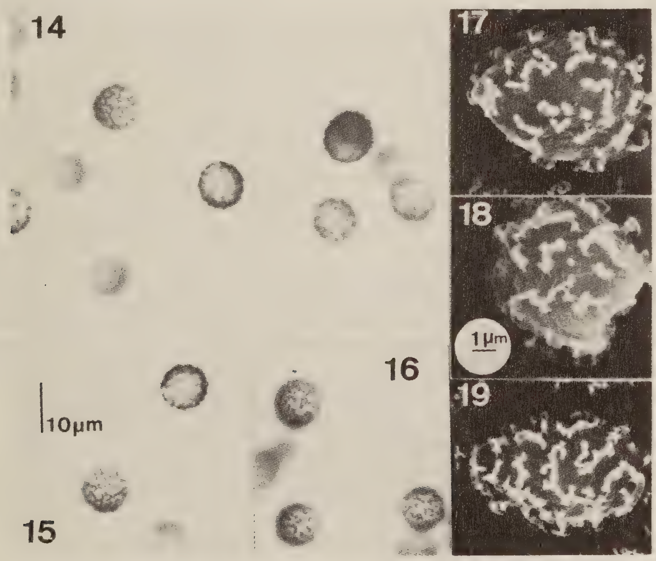
In Spain we only know the record of CHAMPION (1983) from the Canary Islands.

MADRID: On wood of *Cistus ladanifer*, la quinta de El Pardo, 12-I-1990, leg. M.C. Díaz and G. Moreno, H.AH 12211.

Badhamia obovata var. dictyospora (Rost.) Lister
= Craterium obovatum Peck

Sporocysts 0,4-0,7 mm in diam., forming extended colonies, stalked or sessile, 0,4-1,4 mm in height. Peridium ash-grey, sometimes calcareous, brown-reddish towards the base which remains like a cup when the dehiscence happens. Stalk erect, dark brown, cylindrical, forming a white collumella. Capillitium dense, radiating from the columella. Spores globose, dark violaceous-brown, showing a well-developed ornamentation of crests which sometimes coalesce into a subreticulation, 12-15 µm in diam.

FARR (1974) places this species in *Craterium*. We agree with MARTIN & ALEXOPOULOS (1969) and NANNENGA-BREMEKAMP (1974) to consider it as *Badhamia obovata* (Peck) S.J. Smith. The variety *dictyospora* differs from the type variety in having spores with a well-developed ornamentation formed by crests which sometimes coalesce to form a subreticulation (Figs. 14-19).



Figs. 14-19. *Badhamia obovata* var. *dictyospora*: spores. (H.AH 12.214)

This taxon is new to the catalogue of *Myxomycetes* of Spain.

BADAJOZ: On wood of *Quercus ilex* ssp. *ballota*, Azuaga, 10-II-1990, leg. J.R. García, H.AH 12213, 12214 and 12215.

CACERES: On leaves of *Quercus ilex* ssp. *ballota*, Tejeda de Tietar, 19-I-1990, H.AH 12212.

Comatricha tenerrima (M.A. Curtis) G. Lister

Typical fructifications are recognized by their fusiform sporocysts with a sharp end, their pale-brown colour, black stalk and pale-brown warted spores of 8-9 µm in diam.

Previously reported from Spain by LÓPEZ-SÁNCHEZ & al. (1986) from the province of Albacete.

CACERES: On dead stem of *Nicotiana* sp., Tejeda de Tietar, 14-XII-1989, H.AH 12084, 12089, 12090 and 12494. Idem, 19-I-1990, H.AH 12088.

Diachea leucopodia (Bull.) Rostaf.

This species is rather common in Northern Spain. We want to point out that it is very close to *Diachea koazei* Yamamoto and to *Diachea synspora* H.Z. Li, described recently from Japan (YAMAMOTO, 1987) and from China (HUI-ZHONG, 1988) respectively. Both species are characterized by the presence of globose to piriform spores which are united into groups; *D. koazei* has spores with a more spinose ornamentation.

CACERES: On leaves and wood of *Alnus glutinosa*, finca "Las Cansinas" (Natural Park of Monfragüe), 21-VI-1989, H.AH 12239.

Diderma rufostriatum Nann.-Brem. & Lado

It agrees macro- and microscopically with the description of NANNENGA-BREMEKAMP & LADO (1985).

At present it is only known from peninsular Spain.

MADRID: On wood of *Cistus ladanifer*, la quinta de El Pardo, 2-II-1990, H.AH 12246.

Diderma testaceum (Schrad.) Pers.

Sporocysts globose to subglobose, gregarious, sessile, 0,4-1,2 µm in diam. Peridium double, the outer layer cartilaginous, flesh-coloured to pale-pinkish, the inner greyish membranous. Columella big, spherical, smooth, orange-coloured. Capillitium brown, ramificated, with some expansions. Spores pale-brown, warted, 8-9 µm in diam.

It has been collected recently in Pontevedra (PORTELA & LADO, 1990)

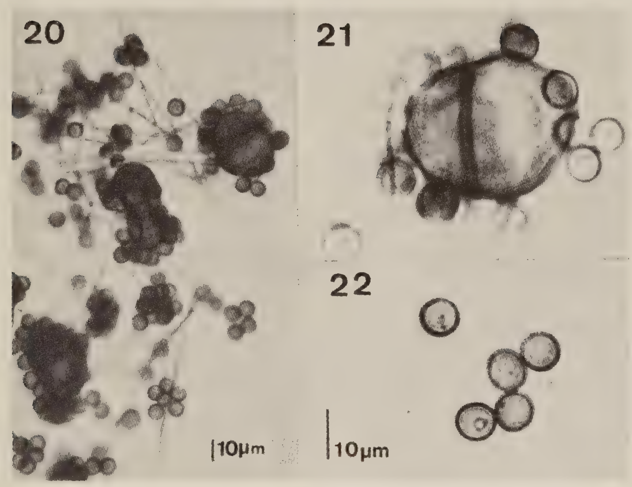
Diderma brunneabasalis Nann.-Brem. & Stephenson recently described (1990), is very close to the pale forms of *D. testaceum*; the two differentiating characters, are the brown wrinkeld base of the peridium and the capillitium with abundant dark expansions.

BARCELONA: On a leaf of a broad-leaved tree, Stª Fe del Montseny, 17-X-1989, leg.: F. Bersan, H.AH 12250.

Didymium serpula Fr.

This taxon forms wide and extended greyish plasmodiocarps. Spores purple-brown, warted, 9-11 µm in diam. Vesicles spherical, brown, up to 35 mm in diam. (Fig. 20-22).

It is only known in Spain from Barcelona (LLISTOSELA & AGUASCA, 1986; VIDAL-FRIGOLA & GRACIA, 1990).

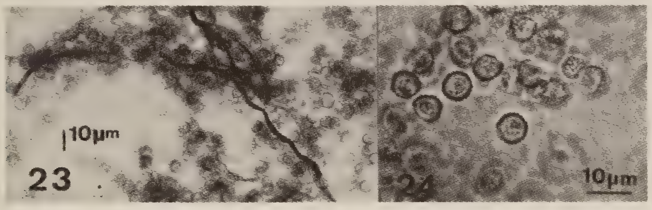


Figs. 20-22. *Didymium serpula*: capillitium, vesicles and spores. (H.AH 12.459).

CACERES: On a leaf of *Quercus pyrenaica*, Sierra de Bernabé del Piornal de Tormantós, 27-IV-1990, H.AH 12459.

Enteridium intermedium (Nann.-Brem.) Farr

This species is characterized by its aethalia, 0,4-1,2 mm in diam. and its pale-brown evanescent peridium. Pseudocapillitium smooth, forming filiform ramifications. Spores yellowish, with a well-developed reticule lacking in a circular zone; 7-9 µm in diam. (Figs. 23-24)



Figs. 23-24. *Enteridium intermedium*: capillitium and spores. (H.AH 12.293).

It has been reported previously from the Canary Islands (LADO & MORENO, 1981) and recently from Galicia (CASTRO & FREIRE, 1988).

MADRID: On wood of a balk, quinta Cervantes, Alcalá de Henares, 28-III-1990, H.AH 12293.

Enteridium splendens var. juranum (Meyl.) Härkönen

Our collection comprises only one aethalium of 1 cm in diam. Peridium dirty-brown, evanescent; pseudocapillitium abundant, formed by filaments and wide plates; spores reticulate, pale-brown, 7-8 µm diam.

It has been cited previously in northern Spain from Pontevedra and Lérida, (ILLANA & al., 1990). In nomenclatural matters we refer to the works of KOWALSKI (1975), FARR (1979) and HÄRKÖNEN (1979). Recently this taxon has been reported from Greenland (GØTZSCHE, 1989).

NANNENGA-BREMEKAMP & YAMAMOTO (1986) refer again to this species in the genus *Reticularia* as *Reticularia splendens* Morgan var. *jurana* (Meylan) Kowalski.

CACERES: On wood of *Quercus suber*, road from la Bazagona to finca Las Cansinas (Natural Park of Monfragüe), 26-V-1989, H.AH 12294.

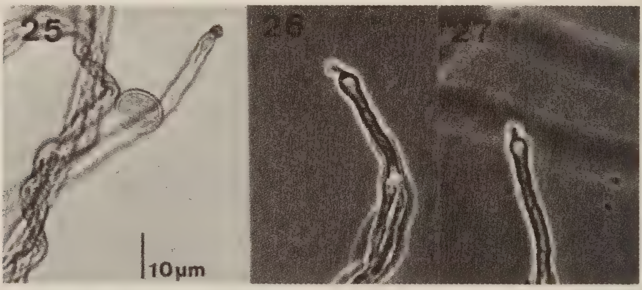
Fuligo septica var. violacea (Pers.) Lister

This variety is characterized by its blue-violaceous aethalia. In Spain we only know the record from Oviedo of LAZARO-IBIZA (1912).

MADRID: On wood of *Pinus sylvestris*, Mirador de los Robledos, Rascafría, 20-IX-1989, leg. A. Guerra, H.AH 12297.

Hemitrichia leiotricha (Lister) G. Lister

This species is characterized by its isolated sporocysts forming cups and with typical microscopic features. Capillitium with an ornamentation formed by 4-5 spirals and with a sort of "sucker" which remembers the head of a Taenia. Spores pale-yellow, smooth to shortly spinose, 11-12 µm in diam. (Figs. 25-27)

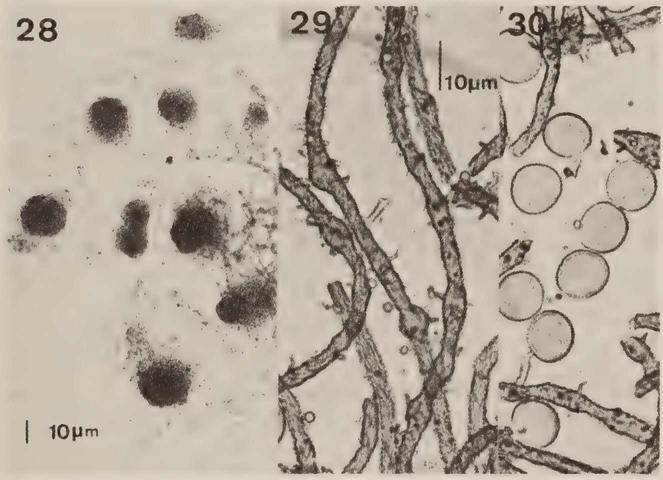


Figs. 25-27. *Hemitrichia leiotricha*: spore and capillitium. (H.AH 12.460)

At present time it is only known from the central zone of Spain (LADO & MORENO, 1978; LADO & MORENO, 1980). Recently, RAMMELOO (1984) has studied this taxon under the electronic microscope. FARR (1974) pointed out the affinities of *H. leiotricha* with other species of the genus.

CACERES: On leaves and woody rests of *Eucalyptus camaldulensis*, mountain pass of la Cañadilla (Natural Park of Monfragüe), 26-IV-1990, H.AH 12460.

Hemitrichia minor var. pardina Minakata
Sporocysts isolated, 0,2-0,4 mm in diam., sessile or with a short and dark stalk. Peridium straw-yellowish with blackish warts which are variable in number and size. Capillitium spinose with only a few free ends, ornamented with 3-4 spirals. Spores warted, yellowish, 10-11 µm in diam. (Figs. 28-30)



Figs. 28-30. *Hemitrichia minor* var. *pardina*: warts of the peridium, capillitium and spores. (H.AH 12.289)

This taxon has not been recorded previously in the spanish literature. NEUBERT & BAUMANN (1987) have published photographs made with the SEM of the capillitium and spores.

CACERES: On dead stem of *Nicotiana* sp., Tejeda de Tietar, 19-I-1990, H.AH 12107, 12143, 12263, 12289, 12298, 12299 and 12360. Idem, 27-IV-1990, H.AH 12461.

OTHER TAXA WHICH ARE NEW TO EXTREMADURA (PROVINCES OF BADAJOZ AND CACERES)

Arcyria pomiformis (Leers) Rostaf.
BADAJOZ: On a branch of *Quercus ilex* ssp. *ballota*, Azuaga, 10-II-1990, leg.: J.R.García, H.AH 12202.

Badhamia gracilis (T. Macbride) T. Macbride
CACERES: On dead cladodes of *Opuntia ficus-indica*, arroyo Barbaón (Natural Park of Monfragüe), 15-XI-1989, H.AH 12051, 12052, 12053 and 12054.

Badhamia macrocarpa (Ces.) Rostaf.

CACERES: On wood of *Quercus pyrenaica*, Sierra de Bernabé del Piornal de Tormantós, 14-XII-1989, H.AH 12203. On dead stem of *Nicotiana* sp., Tejeda de Tietar, 14-XII-1989, H.AH 12204.

Badhamia utricularis (Bull.) Berk.
BADAJOZ: On a plank of *Quercus* sp., finca "Zurrón", Azuaga, 10-XII-1989, leg.: J.R. García, H.AH 12216.

Comatricha elegans (Racib) G. Lister
CACERES: On bark of *Eucalyptus camaldulensis* after 32 days in moist chamber, mountain pass of la Cañadilla (Natural Park of Monfragüe), 27-IV-1990, H.AH 12497 and 12499.

Cribraria cancellata (Batsch) Nann.-Brem.
BADAJOZ: On stem of *Nerium oleander*, arroyo Argallón, Azuaga, 10-XII-1989, leg.: J.R. García, H.AH 12231.

Dictydiaethalium plumbeum (Schum.) Rostaf.
BADAJOZ: On wood of a broad-leaved tree, Azuaga, 10-II-1990, leg.: J.R. García, H.AH 12238.

Didymium bahiense Gottsberger
BADAJOZ: On rests of *Juncaceae*, Azuaga, 8-VII-1989, leg.: J.R. García, H.AH 12500.

Didymium difforme (Pers.) Gray
BADAJOZ: On wood, Azuaga, 10-II-1990, leg.: J.R. García, H.AH 12261.

Didymium muscorum Lakhanpal & Mukerji
BADAJOZ: On wood, arroyo Argallón, Azuaga, 10-II-1990, leg.: J.R. García, H.AH 12269 and 12270.

Didymium squamulosum (Alb. & Schwein.) Fr.
BADAJOZ: On dried umbelas of *Umbeliferae*, arroyo Argallón, Azuaga, 21-I-1989, leg.: J.R. García, H.AH 12280. Idem, on *Rubus* sp., H.AH 12281. Idem, on rests of *Poaceae*, H.AH 12282. Idem, on cork of *Quercus suber*, 10-II-1990, H.AH 12283. Idem, on wood, 21-I-1990, H.AH 12284.

Didymium trachysporum G. Lister
CACERES: On stem of *Nicotiana* sp., Tejeda de Tietar, 19-I-1990, H.AH 12285, 12286, 12288, 12289, 12290 and 12291. Idem, 27-IV-1990, H.AH 12264 and 12287.

Enerthenema papillatum (Pers.) Rostaf.
CACERES: On a piled trunk of *Pinus pinaster*, mountain pass la Cañadilla (Natural Park of Monfragüe), 12-XII-1989, H.AH 12581.

Lamproderma scintillans (Berk. & Br.) Morgan
BADAJOZ: On trunk and leaf of *Nerium oleander*, arroyo Argallón, Azuaga, 10-XII-1989, leg.: J.R. García, H.AH 12301. Idem, 21-I-1990, H.AH 12302.

Licea minima Fr.
CACERES: On wood of *Eucalyptus camaldulensis*, mountain pass of los Castaños, 19-I-1990, H.AH 12492.

Physarum brunneolum (Phill.) Massee

CACERES: On leaves of Quercus pyrenaica, Tejeda de Tietar, 19-I-1990, H.AH 12160, 12161 and 12326. Idem, Sierra de Bernabé del Piornal de Tormantós, 27-IV-1990, H.AH 12325.

Physarum cinereum (Batsch) Pers.

BADAJOZ: On leaves of *Populus nigra*, arroyo Argallón, Azuaga, 10-XII-1989, leg.: J.R. García, H.AH 12327.

CACERES: On a leaf of *Viburnum tinus*, arroyo Barbaón (Natural park of Monfragüe), 14-XI-1989, H.AH 12165. On wood of *Eucalyptus camaldulensis*, mountain pass of los Castaños, 19-I-1990, H.AH 12169.

Physarum compressum Alb. & Schwein.

CACERES: On wood of *Quercus suber* and on *Inonotus cuticularis*, Tejeda de Tietar, 19-I-1990, H.AH 12329.

Physarum pusillum (Berk. & M.A. Curtis) G. Lister

BADAJOZ: On stem of *Rubus* sp., Azuaga, 21-I-1990, leg.: J.R. García, H.AH 12181.

CACERES: On stem of *Nicotiana* sp., Tejeda de Tietar, 14-XII-1989, H.AH 12183.

Physarum straminipes Lister

CACERES: On stem of *Nicotiana* sp., Tejeda de Tietar, 19-I-1990, H.AH 12319, 12341 and 12507. Idem, 27-IV-1990, H.AH 12342, 12343, 12506 and 12509.

Stemonitis axifera (Bull.) T. Macbride

BADAJOZ: On wood of *Pinus pinaster*, Azuaga, 8-VII-1989, leg.: J.R. García, H.AH 12501.

Trichia varia (Pers.) Pers.

BADAJOZ: On wood, arroyo Argallón, Azuaga, 29-IV-1990, leg.: J.R. García, H.AH 12350.

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A NEW FALSE TRUFFLE IN THE GENUS TRAPPEA (HYSTERANGIACEAE)

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ABSTRACT

Trappea pinyonensis sp. nov., is described from the southwest United States in association with pinyon pine. Its relationship to the two species now included in the genus and some notes on its ecology are discussed.

INTRODUCTION

In the course of developing a hypogeous mycoflora for the coniferous forests of the arid southwestern United States (States,1983 1984), several important taxa of uncertain taxonomic placement were encountered. One of these, a hysterangioid false truffle with smooth bacilloid spores was found to be widespread in the pinyon-juniper woodlands of Arizona, Colorado, New Mexico and southern Utah.

Recently Castellano (1990) segregated the genus *Trappea* from *Hysterangium* to accomodate two species, *T. darkeri* and *T. phillipsii*, both possessing smooth bacilloid spores and a layer of sterile locules positioned below the peridium. Following a careful study of representative collections of these species and of related *Hysterangium* species, I have concluded that the undescribed taxon associated with pinyon is best placed in *Trappea* and is described here as a new species, *Trappea pinyonensis* States. Preliminary observations on its distribution and ecology are included.

The description is based on fresh and dried basidiocarps mounted in water or 5% KOH. Results of color reactions in KOH and iron salts, as well as visual determination of basidiocarp coloration are recorded as capitalized color names from Ridgway (1912) color standards and equivalent Munsell color notations (in parenthesis) as found in Rayner (1970). Collections cited are deposited in the mycological collection of the Deaver Herbarium, Northern Arizona University (ASC) and a portion of the type is deposited in the Oregon State University herbarium (OSC).

Trappea pinyonensis States, sp. nov.

BASIDIOMATA parvae, circa 0.2-1.5 (2.0) cm crassae, subsphericae vel irregulares, plicatus vel sulcatus siccate, rhizomorphibus magnus ramosus affixae; superficie laeve sed leniter coactoidea, hyphis hyalinis crystallis incrustatus, ablidae vel salmonaceae, subroseo-bulbalinae siccate. PERIDIUM persistens, 160-200 (350)μm crassum, hyphis hyalinis, in crassitie varium, intertextis composito. GLEBA eleganter gelatinosa, friabilis siccati, glauca vel griseo-olivacea; loculis vacuis, labrinthiformibus, strato loculis sterilibus sine magno discrimini; septis circa 15-25μm crassis, hyphis gelatinosis, hyalinis compositis. COLUMELLA semipellucidae vel albidae, dendroidea, subpercurrens. BASIDIA sex et- octosporae, subclavata cylindracea vel irregulariter ventricosae. SPORAE angustae ellipsoidae vel oblongae, laeves, cumulae olivacea-bulbalinea, 4.7-6.0 x (1.5) 2.0-2.5μm.

HOLOTYPUS: USA: Arizona, Walnut Canyon National Monument, Coconino County, in loci aranosi a *Pinus edulis* associata, States AHF-530, 10 October 1986. In herbarium cryptogamium Northern Arizona University (ASC) conservata.

BASIDIOMES small, highly variable in size when mature, generally 0.2-1.5 (2.5) cm in diameter, subglobose when young, becoming irregularly shaped, folded and sunken at maturity and upon desiccation, attached by one (sometimes several) large cord-like rhizomorphs arising from an extensively branched rhizomorphic network; surface smooth to velvety, initially white, clay white to Salmon Buff (7.5YR/7.8/6.0), pinkish on bruising, drying Light Pinkish Buff (1.5Y/8.8/3.5), staining blue-green (Verdegris Green, 10G/5.2/6.5) to Light Grayish Olive (4Y/5.7/1.0) in FeSO4, negative color reaction in KOH but Vinaceous (7.5RP/6.7/5.7) when FeSO4 is also added, exposed hyphae furfuraceous and encrusted with crystalline particles.

PERIDIUM persistent, 160-200 (350)μm thick, composed of tightly interwoven hyphae near the surface; hyphae hyaline with prominent clamp connections, becoming swollen and partly pseudoparenchymatous above the gleba, gelatinized and interspersed in a gelatinous matrix as they descend into the trama.

COLUMELLA gelatinous, semi-translucent to whitish, branched from the base, subpercurrent, composed of hyaline gelatinous hyphae, indistinct from the trama except for the generally continuous veins that radiate towards the peridium.

GLEBA dry to slightly gelatinous when young, deliquesing centrally at maturity, Glaucous (7.5GY/8.0/2.0)) to Corydalis Green (8GY/7.0/2.5) drying Light Grayish Olive (5Y/5.8/2.0) to Grayish Olive (5Y/4.8/2.5), slow to gelatinize and friable when sectioned; locules generally 200-250 x 40-50μm but variable and irregular (labrinthiform); the layer of sterile locules (typical of other species in the genus) found just within the peridium often poorly developed and represented by clusters of terminally inflated hyphae in young basidiomes; tramal septa 15-25μm wide between locules but thicker near the interface with the peridium, composed of thin-walled clamped hyphae that are 3.5-8.0 μm in diameter and are imbedded in a gelatinous matrix.

BASIDIA clavate to irregularly cylindrical, thin-walled and hyaline, 15-25 x 4.3-6.3μm (ave.19.8 x 5.35μm), clamped at the base, 6-8 spored, sterigmata indistinct.

SPORES smooth, elongate-ellipsoid to oblong, thin-walled, 5.0-6.0 x (1.5) 2.0-2.5μm, with mean l/w = 5.4 x 2.35μm, subsessile and long persistent on basidia, hyaline singly, in mass olive buff when mounted in water and honey yellow in KOH.

MATERIAL STUDIED: ARIZONA: Coconino Co.: HOLOTYPE (ASC) (OSC) States AHF-530, Walnut Canyon National Monument, hypogeous in thick litter underneath *Pinus edulis* canopy, 10 October 1986; PARATYPES States AHF-530, States AHF-454; States AHF-485, States AHF-551. Navajo Co.: States AHF-427. COLORADO: Garfield Co.: Acasi 385, 386,390. NEW MEXICO: San Juan Co.: States NMHF-6. Taos Co.: States NMHF-4. UTAH: San Juan Co.: States UTHF-19.

DISCUSSION

T. pinyonensis basidiomes are produced in both spring and fall and are typically found immeshed within an extensive rhizomorphic network which binds together the needle litter layer beneath the canopy of pinyon pine. In this regard they are not specifically hypogeous in the classic sense (eg. below ground). One finds them by carefully sifting through deep litter mats, following the conspicuous white, pink-staining rhizomorphs. The mycelium is often found to copiously cover needles and old seed coats. The latter are frequently mistaken for basidiomes. The collapsed nature of the basidiome at maturity and on drying seems to be a distinctive feature of the species.

It does not appear that this species is mycorrhizal with pinyon. Attempts by both Acasi (personal communication) and myself to synthesize mycorrhizae on seedlings were unsuccessful and, in many instances, the seedlings appeared to be parasitized and killed by the mycelial inoculum. Similar results were obtained with isolates of *Sclerogaster xerophilus* from pinyon (Lanphear 1985). This fungus also inhabits the duff layer as opposed to a strictly soil habit, thus indicating a potential saprotrophic role.

Trappea pinyonensis differs from the other *Trappea* species in the weakly developed layer of sterile locules in the basidiome at maturity. It can be easily distinguished from *T. darkeri*, also found in association with pinyon pine, by the staining reactions of the peridium and rhizomorphs and its relatively larger spores. Although it shares these two features with *T. phillipsi*, it is clearly different in the following respects: the friable gleba of *T. pinyonensis* crumbles (rather than remaining hard and resistant) when sectioned, this due in part to larger locules and to tramal tissue which is slow to gelatinize; the basidia are characteristically more clavate than cylindrical; a differently colored spore mass in water and KOH; color of the gleba and the lower intensity and persistence of the bruising reaction of the peridium. It is interesting that *T. phillipsii* has been reported only from California where it is also a potential saprotroph on decayed wood (Castellano 1990).

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STUDIES IN THE GENUS CLADOSPORIUM SENSU LATO. III. CONCERNING CLADOSPORIUM CHLOROCEPHALUM AND ITS SYNONYM CLADOSPORIUM PAEONIAE, THE CAUSAL ORGANISM OF LEAF-BLOTCH OF PEONY

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ABSTRACT

Cladosporium paeoniae Passerini, the causal organism of leaf-blotch of *Paeonia* spp., is shown to be conspecific with *Cladosporium chlorocephalum* (Fres.) Mason et M.B. Ellis, a fungus occurring on dead stems and leaves of the same host genus. The former, which is of widespread occurrence in the United States, represents a semi-macronematous form of the latter. *Cladosporium chlorocephalum* has date priority and accordingly *C. paeoniae* is reduced to synonymy. The fungus has been isolated in pure culture and is described and illustrated from nature and *in vitro*.

INTRODUCTION

For well over one hundred years the binomial *Cladosporium paeoniae* has been applied to the fungus causing well-defined, necrotic leaf-blotch symptoms on living leaves of species of *Paeonia* L., such as *P. albiflora* Pall. [= *P. edulis* Salis., = *P. lactiflora* Pall.], *P. montan* Sims [= *P. arborea* Donn, = *P. suffruticosa* Andr.], and *P. officinalis* L. The name has been widely used in the United States, judging by the large number of herbarium specimens identified as such deposited in the National Fungus Collections [BPI] (see below) and Anon (1960). It continues to be accepted up to the present [see, for example, Farr *et al.*, 1989]. No mention was made of *Cladosporium paeoniae*, however, in the accounts of *Cladosporium* Link published by Ellis (1971, 1976), nor by Ellis and Ellis (1985) in their treatment of microfungi on land plants. The fungus was first described, very briefly, by Passerini (1876), from collections made on leaves of *P. albiflora* [as *P. edulis*] in Parma and Gorizia, Italy. Material collected by G. Passerini on leaves of *P. officinalis* at Parma in July 1876 was issued as de Thümen Mycotheca universalis no. 670. Saccardo (1882), in a treatment of fungi from outside Europe, reported *C. paeoniae* to occur on leaves of *P. anomala* L. in subalpine forests around Minusinsk, Siberia, and described it based on material received from N. Martinoff. Saccardo (1886) subsequently republished Passerini's description, naming the host as *P. officinalis*. In addition, Saccardo (1886) established the varietal name *paeoniae anomalae* Sacc. for the Siberian entity and repeated its description. In Passerini's original description, no mention was made of conidium size, but conidia were said to be

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one or two-septate. Saccardo (1882) noted that conidia of the fungus on *P. anomala* from Siberia were, with time, three-septate, and 15 - 22 X 6 µm in size. Lindau (1907) provided a German translation of the original descriptions of both *P. paeoniae* and *P. paeoniae* var. *paeoniae anomalae* but, although reporting collections of the former from a number of localities in Germany, added no new information, even on conidium size. Subsequently *C. paeoniae* has been reported from, or collections made in, many areas of the world.

Leaf-blotch of peony was reported from North America in the early part of this century (Whetzel, 1915; Coulson, 1923) but few additional facts concerning the causal fungus, or disease epidemiology, were published until the investigation of Meuli (1937). In Europe, during the same period, a number of exsiccati of *C. paeoniae* were issued [e.g. Kabāt and Bubāk, Fungi imperfecti exsiccati no. 396; D. Saccardo, Mycotheca italica no. 1186; Sydow, Mycotheca germanica nos 196 and 2447; and Săvulescu and Sandu, Herbarium Mycologicum Romanicum Fasc. VI, no. 298]. Martin (1929) reported *C. paeoniae* to occur on abortive buds, while Weiss (1932) implicated the fungus in blossom infection. Meuli (1937) reported a study of peony leaf-blotch in which *C. paeoniae* was isolated in pure culture and its morphology determined. Aspects of its physiology and pathogenicity were also investigated. An account of disease symptoms indicated conspicuous dark purple blotches to occur on leaves and elongated, reddish brown streaks, with slightly diffuse margins, to occur on young, green stems. *Cladosporium paeoniae* was illustrated and described as producing chains of small, round to lemon-shaped conidia and ellipsoid, sometimes one-septate, ramo-conidia. Conidial measurements from colonies grown on malt agar were given. The fungus was said not to sporulate in nature during the growing season except in the presence of favorable moisture conditions following rains in spring and late fall. Mycelium was thought to overwinter in plant material and primary infection in spring to originate from this source.

De Vries (1952) considered *C. paeoniae* in his study on *Cladosporium*. Like Meuli, he examined the fungus *in vitro* (from an isolate deposited at the Centraalbureau voor Schimmelcultures in December 1924 by L. Montemartini [CBS 118.24]). Three exsiccati [those of Sydow, Săvulescu and Sandu, cited above] were also examined. Conidial measurements made from these were compared with those of conidia from the CBS isolate and those cited in Meuli's description. The Montemartini strain was reported to sporulate very poorly and the conidia produced to correspond to those of *Cladosporium cladosporioides* (Fres.) de Vries. It was also noted that the conidia were unicellular and that they differed in that regard from Lindau's description [loc. cit.] where they were described as being two or three-celled. [In his translation of the original Passerini description, Lindau had changed "one or two-septate" to "two- or three-celled"]. Based on comparison of conidium size and allowing for variation due to substrate differences and conidial age, it was concluded that there was fairly good agreement among the CBS isolate, the exsiccati, and what had been reported by Meuli. No further comment was made on similarity with *C. cladosporioides*, but when grown at 25 C in the dark, colonies of that species were found to grow three times faster than those of *C. paeoniae*. De Vries noted conidiophores of *C. paeoniae* to be distinctly shorter than those of *C. herbarum* Link, but a strain of the latter was found to grow at the same rate as *C. paeoniae*. In regard to conidium shape, de Vries stated that *C. paeoniae* should not be confused with *C. sphaerospermum* Penz. The spherical conidia observed by Meuli were said to be young and to become longer with age. De Vries considered var. *paeoniae anomalae* to be probably synonymous with *C. paeoniae*,

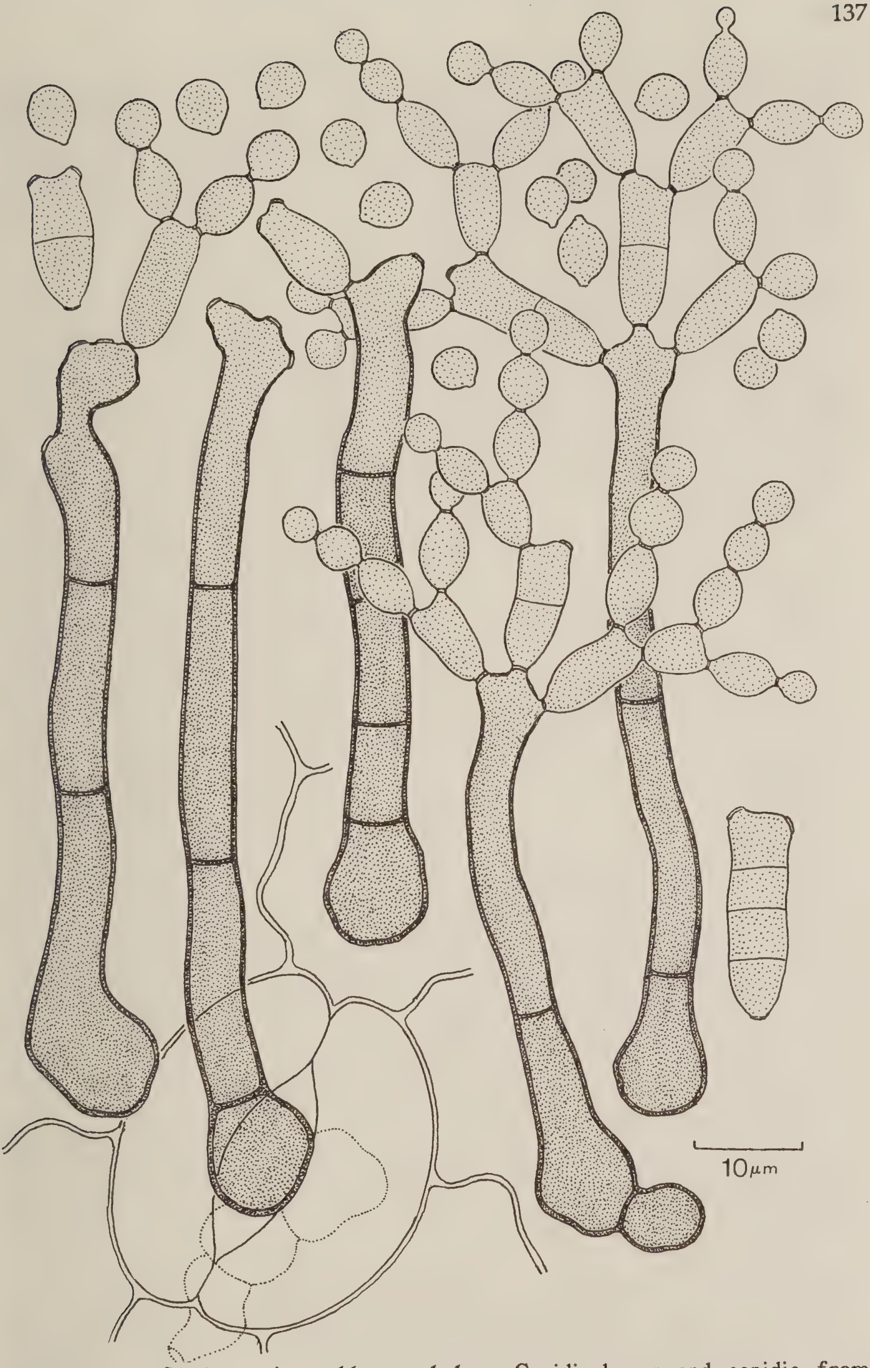


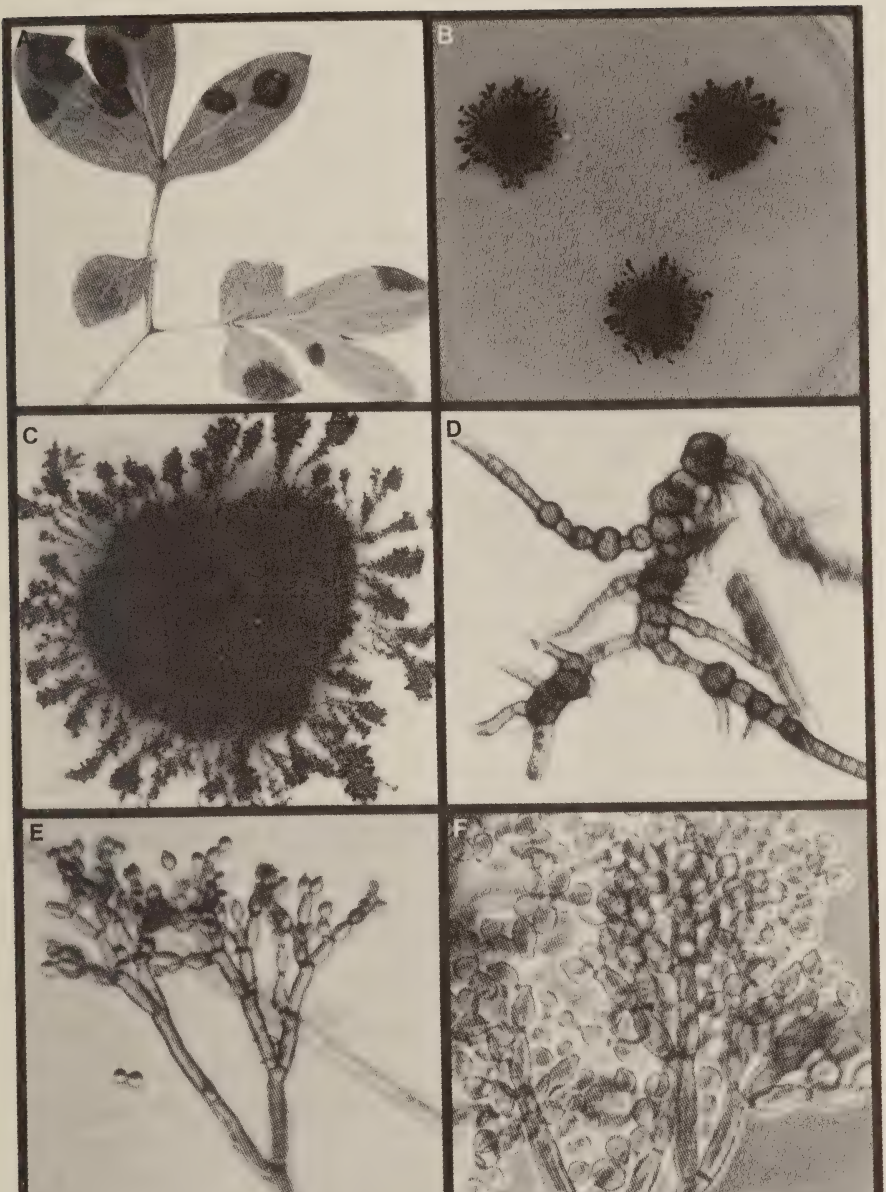
FIGURE 1. *Cladosporium chlorocephalum.* Conidiophores and conidia from nature on leaves.

but given the conidial size and septation cited by Saccardo (1882), it is difficult to be certain whether this is the case. Reexamination of its type is necessary to determine this. On the basis of possession of shorter conidiophores in nature and production of "well circumscribed leaf spots", *C. paeoniae* was considered by de Vries to be a distinct species.

Another species of *Cladosporium*, *C. chlorocephalum* (Fres.) Mason et M.B. Ellis is typically found on dead stems and leaves of *Paeonia* spp. This was originally described by Fresenius (1850) and placed in the genus *Periconia* Tode as *P. chlorocephala* Fres. Morphologically it is quite similar to species of that genus in possessing macronematous, long, thick, dark brown conidiophores bearing discrete, monoblastic or polyblastic conidiogenous cells on short, appressed branches toward the extreme apex. This gives the appearance of a stipe and spherical head in the manner characteristic of *Periconia*. The fungus also resembles *Periconia* in forming extensive, mostly immersed or partly erumpent, dark brown stromata from which conidiophores originate solitarily or in groups of a few. The presence of stromata and immersed mycelium gives rise to blackened areas on colonized stems, similar to those associated with such species as *P. byssoides* Pers., and *P. cookei* Mason et M.B. Ellis.

Mason and Ellis (1953), in their revision of British species of *Periconia*, concluded that *P. chlorocephala* was more appropriately classified in *Cladosporium*, and accordingly, transferred it to that genus. It produces long, branched chains of mostly smooth, relatively small, very pale brown conidia, each bearing one or more slightly projecting scars at the point of attachment. These are quite unlike the usually much larger verruculose or echinulate conidia typical of *Periconia*. A study of this fungus *in vitro* revealed that it readily produces micronematous conidiophores bearing ramo-conidia and numerous chains of oval or spherical conidia when grown on malt agar. These are essentially identical to those produced by *C. paeoniae*, although no mention was made of that species. Macronematous *Periconia*-like conidiophores were found to be produced in culture on agar blocks held between a slide and coverslip for a month, or on drying out old tube cultures. A number of herbarium collections of *C. chlorocephalum* were examined, several of which had been issued as exsiccati, but misidentified as species of *Periconia*, particularly *P. atra* Corda [for example, Desmazières, Crypt. France, Ser. 1, no. 1621, and Roumeguère, Fungi Gallici Exsiccati, no. 1893] and *P. byssoides* [for example, Westendorp and Wallays, Herb. Crypt. Belg. no. 48]. Interestingly, among these specimens was a collection made on *Paeonia tenuifolia* L. at Parma, Italy, in March 1889 by G. Passerini and issued as Roumeguère, Fungi Selecti Exsiccati no. 5087 under the name *Haplographium chlorocephalum* [*H. chlorocephalum* (Fres.) Grove, see below]. An earlier collection, made at Parma in January 1873 and named *Periconia chlorocephala*, was issued as Erb. Critt. Ital. Ser. 11, no. 894. It is apparent that although the conidia of the macronematous form, which occurs predominantly on stems, and those of the semi-macronematous form found on

PLATE 1. *Cladosporium chlorocephalum*. A, typical leaf-blotch on peony; B, 4-week-old colonies on MEA; C, close-up of colony showing arachnoid margin; D, immersed chlamydospore-like cells at colony periphery; E-F, semi-macronematous conidiophores from culture, showing extensive branching.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leaves are closely similar, the two have long been thought to represent different fungi.

During the course of our recently initiated studies in the genus *Cladosporium* (Morgan-Jones and McKemy, 1990; McKemy and Morgan-Jones, 1990), we have had opportunity to isolate in culture the form causing blotch disease of peony leaves, traditionally named *C. paeoniae*, from a collection made in Jackson County, Alabama. Comparison of this with numerous other collections on leaves and two of the *Periconia*-like form on dead stems made in the United Kingdom and cited by Mason and Ellis (1953) [IMI 48108 and IMI 48159, see below] has shown *C. paeoniae* and *C. chlorocephalum* to be conspecific, representing different manifestations of the same polymorphic anamorph. Colonies derived from conidia produced by semi-macronematous conidiophores on leaves were found to form macronematous conidiophores following maintenance for eight weeks on 2% malt agar [Difco]. Since the binomial *Periconia chlorocephala* [the basionym of *C. chlorocephalum*] predates *Cladosporium paeoniae* it has priority. A new, comprehensive description of the fungus is published herein.

TAXONOMIC PART

Cladosporium chlorocephalum (Fres.) Mason et M.B. Ellis, *Mycol. Pap.* 56: 123-126, 1953 (Plates 1 & 2, Figures 1 & 2).

≡ *Periconia chlorocephala* Fres., Beitrage zur Mykologie, 1: 21, 1 850.

≡ *Haplographium chlorocephalum* (Fres.) Grove, *Sci. Gossip*, 21: 198, 1885.

≡ *Graphiopsis chlorocephala* (Fres.) Trail, *Scot. Nat.* 10: 75, 1889.

= *Periconia ellipsospora* Penzig & Saccardo, *Atti Ist. Veneto* 6, ser. 2: 596, 1884.

= *Haplographium chlorocephalum* (Fres.) Grove var. *ovalisporum* Ferraris, Flora Ital. Crypt. Hyphales: 875, 1914.

= *Cladosporium paeoniae* Passerini, *Justs. Jahresber.* 4: 235, 1876.

? [= *Cladosporium paeoniae* Pass. var. *paeoniae anomalae* Saccardo, *Syll. Fung.* 4: 351, 1886].

Leaf blotches visible on both surfaces, appearing as circular to oval or somewhat irregular discolored areas (Plate 1, A), at first pale, dull brown, becoming chocolate brown on the adaxial surface, remaining paler underneath, eventually becoming violet brown with age, up to 3 cm long, 2 cm wide, margin definite or somewhat indefinite. Mycelium immersed in the host tissue, composed of abundantly branched, septate, hyaline to subhyaline or very pale brown, 2-3 µm wide hyphae, at first intercellular, becoming intracellular as leaf spot tissue becomes necrotic. Hyphae in substomatal cavities somewhat knotted, inflated, producing a small stroma of mid to dark brown, subglobose, 8-12 µm wide cells, from which semi-macronematous conidiophores arise singly, in pairs or in small fascicles (Plate 2, A; Figure, 1). Colonies on stems at first

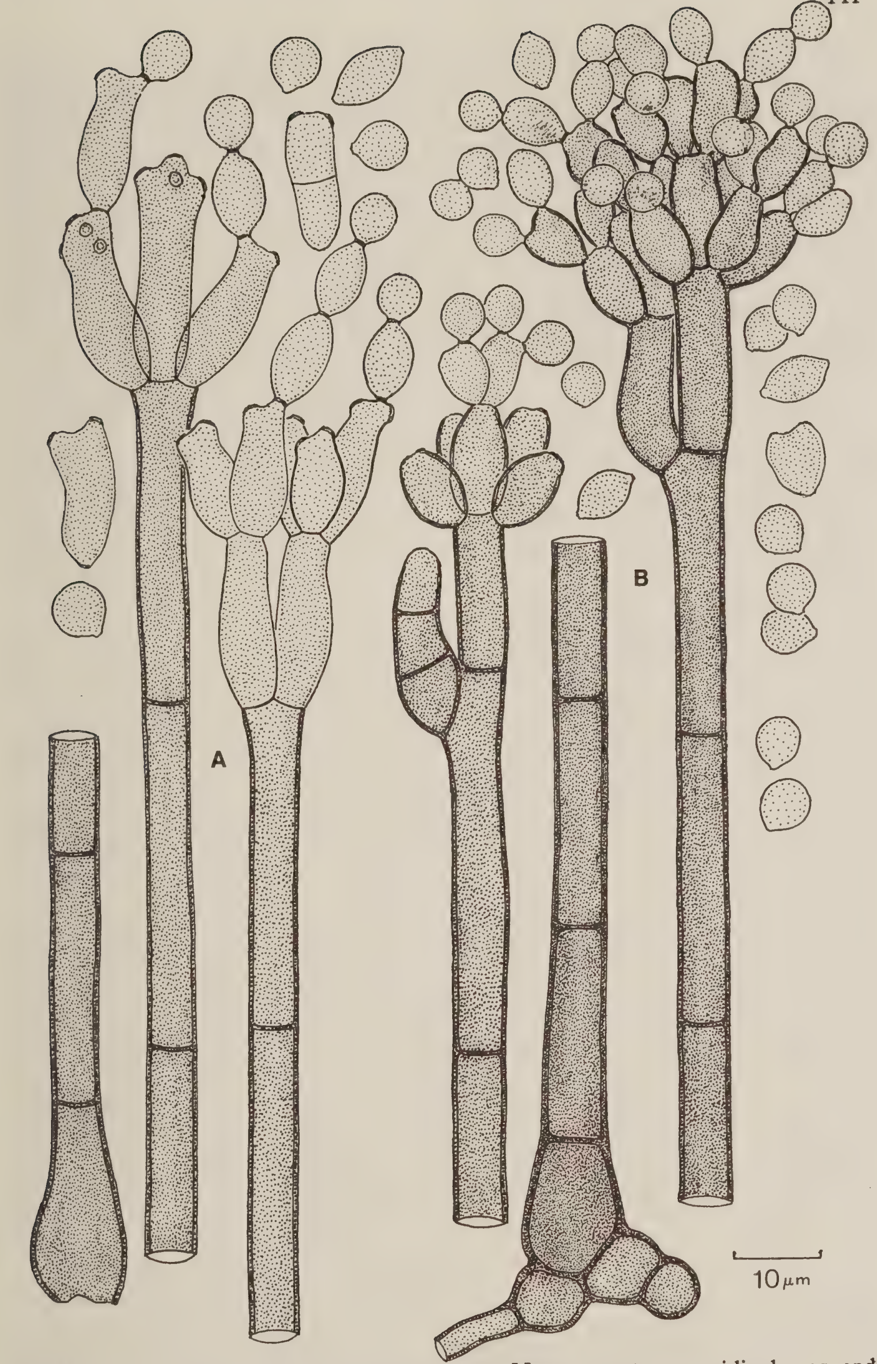
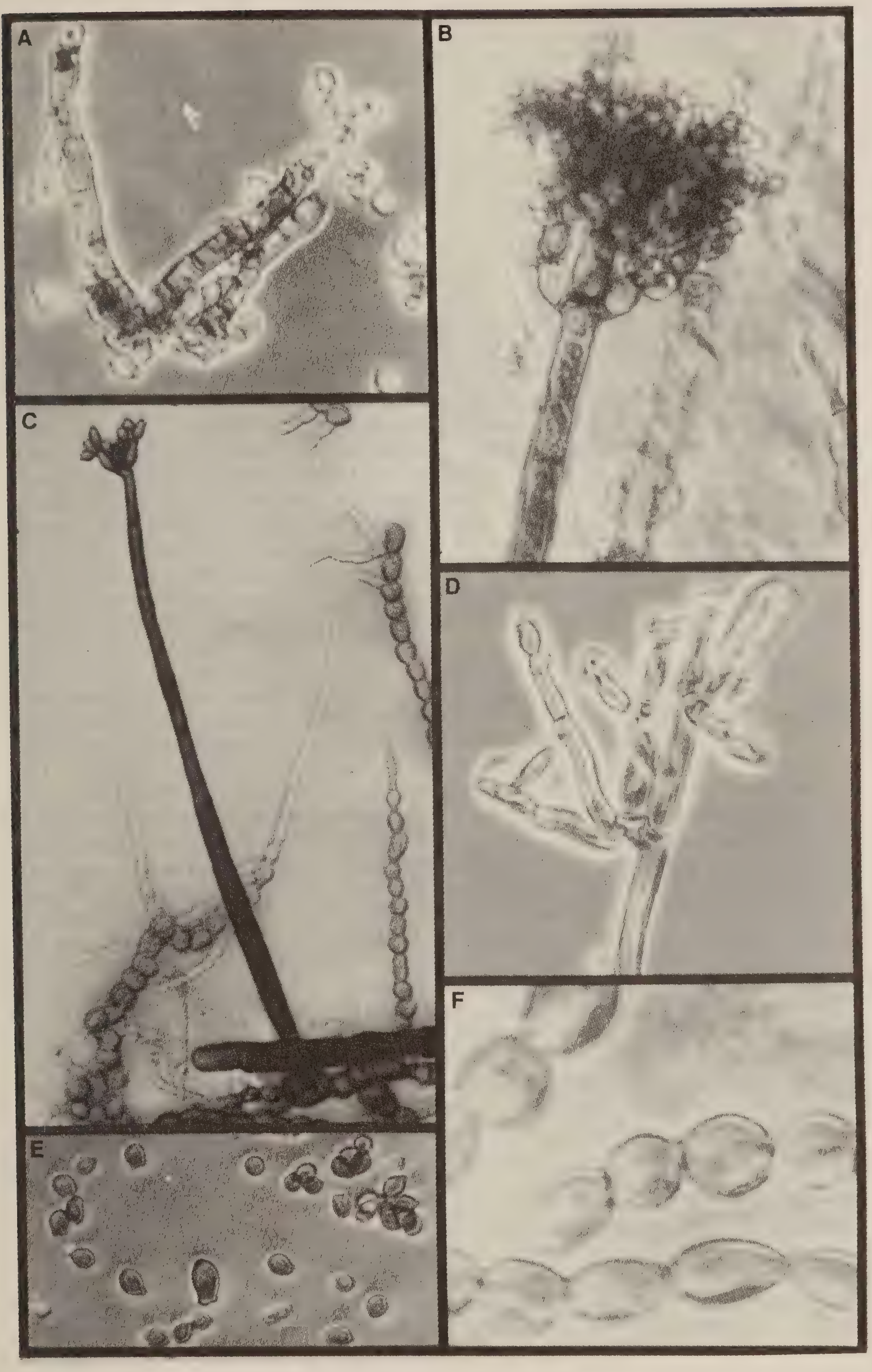


FIGURE 2. *Cladosporium chlorocephalum*. Macronematous conidiophores and conidia. A, from culture on MEA; B, from nature on dead stems.

appearing as reddish-brown streaks, later becoming olivaceous brown to black, effuse, sometimes extensive and encircling the periphery or linear, often covering several centimeters. Mycelium immersed, composed of branched, septate, subhyaline to pale brown, 2.5-7 µm wide hyphae. Stromata frequently formed below the stem surface, up to 320 µm long, composed of one to several layers of thick-walled, mid to dark brown, 7-18 µm wide cells, giving rise to macronematous conidiophores singly or in groups. Colonies on potato dextrose agar (PDA) [Difco] grown at 25C attaining a diameter of 13 mm and 18 mm after 7 and 14 days, respectively, densely lanose, coloration varying from Olive to Dark Green [2F4 to 30F6] (Kornerup and Wanscher, 1978), margin even at first, later somewhat irregular. Colony reverse Bronze Green to Olive Grey [30F3 to 1F2]. Colonies on PDA at 20C and 30C attaining a diameter of 18 mm and 8 mm after 14 days; appearance and coloration at 20C similar to those at 25C. Colonies on malt extract agar (MEA) [Difco] (Plate 1, B and C) slow-growing, attaining a diameter of 38 mm after 5 weeks at 25C, compact, densely lanose to somewhat tufted but with less aerial mycelium than on PDA, sporulating abundantly, Dark Green [30F6], reverse Parsley Green [30F8] to black, prominently arachnoid at the periphery with irregular, feather-like extensions, bearing two types of conidiophores. Colonies on MEA forming numerous submerged, radiating chains of inflated, chlamydospore-like, relatively thick-walled, pale to mid brown cells (Plate 1, D; Plate 2, C and F) that are sometimes aggregated into loose, stromata-like clusters. Conidiophores in nature of two types: semi-macronematous, occurring on leaves, and distinctly macronematous, *Periconia*-like, occurring on stems. Semi-macronematous conidiophores produced on leaves (Plate 2, A; Figure 1) more or less erect, straight and moderately rigid or somewhat flexuous, smooth, cylindrical, attenuating slightly towards the apex, thick-walled, mostly simple, occasionally with a lateral branch near the apex, septate, often closely (Plate 2, A), pale to mid brown, sympodial, bearing a number of ramo-conidia apically or subapically, up to 110 µm long, 5-8 µm wide, often distinctly bulbous at the base, frequently arising from inflated, chlamydospore-like cells. *Periconia*-like conidiophores in nature (Plate 2, B; Figure 2, B), macronematous, mononematous, erect, straight, rigid to very slightly flexuous, smooth, attenuating gradually towards the apex, thick-walled, dark brown, somewhat paler distally, sympodial, branched, bearing a number of ramo-conidia apically or subapically, up to 600 µm long, 16-22 µm wide at the base, 5-10 µm wide below the conidial head, arising from single, inflated chlamydospore-like cells or stromata. Macronematous conidiophore primary branches originating immediately below the first or second septum from the apex, cylindrical to ellipsoid, continuous or septate, appressed against the stipe or slightly divergent, single, in pairs or, where located below the terminal septum, in verticils, 10-20 µm X 6-8.5 µm; secondary branches more or less oval. Conidiogenous cells holoblastic, polyblastic, integrated or discrete, intercalary or, more often, terminal; where terminal, indeterminate, sympodial, bearing a number of flat, thickened scars. In culture, conidiophores micronematous, semi-macronematous

PLATE 2. *Cladosporium chlorocephalum*. A, semi-macronematous conidiophores from nature on peony leaves; B, terminal portion of macronematous conidiophore from nature; C, macronematous conidiophore from culture; D, micronematous conidiophore from culture showing branching patterns and multiple conidiogenous loci; E, conidia; F, chains of chlamydospores.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or macronematous, mononematous. Where semi-macronematous (Plate 1, E and F), flexuous, pale olive-green, generally thinner walled and paler than in nature, smooth or verruculose, up to 350 µm long, regularly septate, often with intercalary cells inflated, frequently branched; branches up to 50 µm long, each originating immediately below a transverse septum, producing abundant chains of conidia (Plate 1, F). Where macronematous (Plate 2, C; Figure 2, A), erect, straight, rigid to slightly flexuous, attenuating gradually towards the apex, thick-walled, septate, dark-brown, bearing fewer branches toward the extreme apex than *Periconia*-like conidiophores produced in nature, up to 500 µm long, 20 (12-15) µm wide at the base, 11 (5-7) µm below the apex, arising from submerged chlamydospore-like, 14-21 µm wide cells. Conidiogenous cells of semi-macronematous conidiophores produced in culture intercalary or terminal (Plate 2, D), often with thickened conidial scars, 1-2 µm in diameter, at the end of small, denticle-like protuberances. Conidia catenate, in long, branched chains. Ramo-conidia in nature cylindrical to clavate or ampulliform, smooth to minutely verruculose, 0-3 septate, mid brown, bearing two to four flat thickened scars, up to 25 (8-15) µm long, 4-6 µm wide; in culture more or less cylindrical, pale greenish brown, often long, 0-4 septate, up to 50 µm in length, mostly 15-20 µm X 4-6 µm wide, with up to 5 terminal, subterminal or lateral scars. Intercalary conidia intermediate in the chains ellipsoidal to somewhat limoniform, or oblong to fusiform, mid brown, smooth or minutely verruculose, 0-1 septate, up to 20 µm long, 3-6 µm wide. Conidia located toward the apex of the chains mostly subglobose to globose, 3.5-4 µm. Intermediate and terminal conidia slightly papillate at point or points of attachment. When mature, following detachment in nature, such conidia often becoming somewhat inflated to 5-6 µm in diameter and more pigmented.

On living and dead leaves and stems of *Paeonia* spp., including *P. arborea* Don., *P. officinalis* L. and *P. suffruticosa* Andr.; Europe, New Zealand and North America. Probably cosmopolitan and occurring wherever peony is grown.

Collections examined: on *P. arborea*, Fürstlicher Park, Sondershausen, Thuringia, Germany, August 20, 1903, G. Oertel, Sydow, Mycotheca germanica no. 196, BPI 427337; on *P. arborea*, Turnau, Bohemia, Czechoslovakia, September 15, 1905, J.E. Kabát, Kabát et Bubák, Fungi imperfecti exsiccati no. 396, BPI 427338; on *P. officinalis*, Parma, Italy, July 1876, G. Passerini, de Thümen, Mycotheca universalis no. 670, BPI 427343; on *P. officinalis*, Fyen, Skaarup, Denmark, September 9, 1880, E. Rostrup, BPI 427341; on *P. officinalis*, Washington, D.C., U.S.A., 1887, B.T. Galloway, BPI 427345; on *P. officinalis*, Champaign, Illinois, U.S.A., August 1, 1888, M.B. Waite, BPI 427350; on *P. officinalis*, Pavia, Italy, 1889, G. Briosi and F. Cavara, BPI 427370; on *P. officinalis*, Königstein, Saxony, Germany, August 1896, W. Krieger, Krieger, Fungi saxonici 1545, BPI 427346; on *P. officinalis*, Centre Point, Iowa, U.S.A., 1896, D.C. Snyder, BPI 427359; on *P. officinalis*, Padova, Italy, August 1902, P.A. Saccardo, D. Saccardo, Mycotheca italica no. 1186, BPI 427367; on *P. officinalis*, Newark, Delaware, U.S.A., July 1903, C.O. Smith, BPI 427362; on *P. officinalis*, Sitka, Alaska, U.S.A., September 6, 1915, J.P. Anderson, BPI 427363; on *P. officinalis*, Westville, Connecticut, U.S.A., September 24, 1919, G.P. Clinton, BPI 427356; on *P. officinalis*, Van Wert, Ohio, U.S.A., August 10, 1921, L.R. Bonnewitz, BPI 427360; on *P. officinalis*, Van Wert, Ohio, U.S.A., August 21, 1921, J.A. Stevenson, BPI 427352; on *P. officinalis*, Topeka, Kansas, U.S.A., July 7, 1922, C.F. Menninger, BPI 427369; on *P. officinalis*, Schlosspark, Tamsel, Brandenburg, Germany, August 15, 1924, P. Vogel, Sydow, Mycotheca germanica no. 2447, BPI 427344; on *P.*

officinalis, Madison, Wisconsin, U.S.A., September 3, 1926, R. Sprague, BPI 427358; on *P. officinalis*, Oltenia, Vâlcea, Romania, August 17, 1930, T. Săvulescu and C. Sandu, Herbarium Mycologicum Romanicum Fasc. VI no. 298, BPI 427361; on *P. officinalis*, Tuskegee, Alabama, U.S.A., August 12, 1935, G.W. Carver, BPI 427365; on *P. officinalis*, Concordville, Pennsylvania, U.S.A., July 18, 1938, F. Weiss, BPI 427351; on *P. officinalis*, Clearwater Lake, Minnesota, U.S.A., September 1, 1942, F. Weiss, BPI 427353; on *P. officinalis*, Lee, Illinois, U.S.A., August 1, 1958, W.G. Solheim, BPI 427340; on *P. officinalis*, Bruceton Mills, West Virginia, U.S.A., September 20, 1953, E.S. Elliott, BPI 427339; on *P. suffruticosa*, Arnold Arboretum, Jamaica Plain, Massachusetts, U.S.A., September 1, 1936, G.D. Darker, FH, BPI 427371; on *Paeonia* sp., Normal, Illinois, U.S.A., August 18, 1882, A.B. Seymour, BPI 427317; on *Paeonia* sp., Chandlerville, Illinois, U.S.A., August 20, 1886, A.B. Seymour, BPI 427315; on *Paeonia* sp., Jackson, Mississippi, U.S.A., April 26, 1922, L.E. Miles, BPI 427322; on *Paeonia* sp., Independence, Missouri, U.S.A., July 13, 1926, W.A. Archer, BPI 427321; on *Paeonia* sp., Osage, Iowa, U.S.A., September 11, 1927, W.A. Archer, BPI 427331; on *Paeonia* sp., Wrangell, Alaska, U.S.A., September 3, 1934, G.F. Gravatt, BPI 427313; on *Paeonia* sp., Ithaca, New York, U.S.A., June 28, 1941, E.P. Imle and P. Brierley, BPI 427324; on *Paeonia* sp., Montreal, Quebec, Canada, August 31, 1943, DAOM 13794, BPI 427308; on *Paeonia* sp., Madison, Wisconsin, U.S.A., September 4, 1952, H.C. Greene, BPI 427312; on *Paeonia* sp., Arlington, Wisconsin, U.S.A., August 14, 1963, H.C. Greene, BPI 427310; on *Paeonia* sp., Lambourne Hill, Perranzabuloe, Cornwall, United Kingdom, December 11, 1951, F. Rilstone, IMI 48108, AUA; on *Paeonia* sp., Threeburrows, Blackwater, Cornwall, United Kingdom, December 20, 1951, R.C. Congdon, IMI 48159, AUA; isol. ex *Paeonia* sp., Christchurch, New Zealand, October 10, 1973, G.J. Hicks, IMI 180118, AUA; on *Paeonia* sp., Jackson Co., Alabama, U.S.A., May 15, 1990, P. Burson, AUA. [Isolate derived from this collection has been deposited at ATCC.]

DISCUSSION

Conidiophores appear to be produced sparsely on leaf-blotches in nature, but can be readily induced to form when infected leaves are incubated for one or two days in a moist chamber [glass petri dish containing filter paper soaked with sterile distilled water]. A large number of the specimens examined, although showing prominent leaf-blotches, bore very few conidiophores. In nature, conidiophores are probably formed only during periods of high humidity in mid to late summer when leaf-blotches are well developed. Our own observations in this regard confirm those of Meuli (1937). The *Periconia*-like macroconidiophore form is produced on dead, blackened stems in late fall or winter and may be the source of inoculum for reinfection of young leaves in the spring. As indicated above, the fungus is probably widespread in distribution, occurring wherever its host is grown. Some question remains concerning its host range within the genus *Paeonia*. Meuli (1937) reported the slender-leafed *P. tenuifolia*, a species which, following an early blooming period, dies down, to be resistant to infection by *C. chlorocephalum*. It should be noted, however, that it has been recorded as occurring on this host (see Roumeguere, Fungi Selecti Exsiccati no. 5087, cited above).

Colonies in culture on MEA and PDA initially form both micronematous and semi-macronematous conidiophores bearing numerous, long chains of conidia. As colonies age, conidiophores become progressively more differentiated and, on MEA, after eight or more weeks, typical long, brown, *Periconia*-like conidiophores are formed from thick-walled, swollen chlamydospore-like cells. Although having fewer apical primary and secondary branches, these are quite similar to those produced in nature on dead stems.

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DICARPELLA DRYINA SP. NOV., TELEOMORPH OF TUBAKIA DRYINA

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SUMMARY

A previously undescribed species of *Dicarpella* was found on overwintered fallen leaves of red oak (*Quercus rubra* L.). Cultures derived from single ascospores produced an anamorph identical to that in cultures derived from a foliar disease of red oak caused by *Tubakia dryina* (Sacc.) Sutton. The name *Dicarpella dryina* sp. nov. and the connection with the anamorph *Tubakia dryina* are proposed.

Tubakia dryina (Sacc.) Sutton was found on *Quercus rubra* L., for the first time in Italy in the summer of 1987, associated with a foliar disease characterized by numerous reddish to dark brown spots on one- and two-year seedlings (Belisario, 1990). The fungus was originally observed by Saccardo (1876) on 'not yet dead' leaves of *Quercus pedunculata* Ehrh. (= *Q. robur* L.) in the Montello wood. He issued the exsiccatum in Mycotheca Veneta n. 555 under the doubted name of '*Stigmella? dryina* Sacc. *minime* Lév.'. In 1878 the same author described the fungus as a new species of *Leptothyrium* Kunze: *L. dryinum* Sacc. (Saccardo 1878a). Concerning the type material above mentioned, he wrote: '*quae Leptothyrium dryinum* Sacc. *sistit*' (Saccardo 1878b). Von Hoehnel (1925) transferred *L. dryinum* to the genus *Actinopelte* Sacc. and restricted the application of *A. dryina* (Sacc.) Hoehn. to European provenances while he established a new species *A. americana* Hoehn. for American specimens.

The genus *Actinopelte* Sacc. was constituted by Saccardo in 1913 on the type species *A. japonica* Sacc. found on leaves of *Castanea vesca* Gaertn. var. *japonica* from Japan. He erroneously considered the fungus an ascomycete since its conidia, exceptionally large in size and globose in shape, were misconceived as monosporic asci as was proved by Theissen (1913). The conidial identity of the large subglobose bodies was also confirmed by

Petrak (1924). In 1945 Limber and Cash presented an extensive review on the morphology, taxonomy and synonymy of *A. dryina*, taking account of the available literature and examination of current collections and herbarium specimens. More recently the taxonomic concepts of the genus *Actinopelte*, including the pathological aspects, have been revised by Yokoyama and Tubaki (1971). In addition to *A. japonica* and *A. dryina*, the latter found on leaves of *Quercus glauca* Thunb., *Q. phillyraeoides* A. Gray and *Castanea pubunervis* Schneid., the authors described the new species *A. rubra* Yokoyama & Tubaki parasitic on living leaves of *Q. phillyraeoides*, *A. subglobosa* on fallen leaves of *Q. glauca* and *A. castanopsis* on leaves of *Castanopsis cuspidata* Schottky. All of the species belonging to the genus *Actinopelte* were transferred by Sutton (1973) under the name *Tubakia* nom. nov., as he noted that the name *Actinopelte* had already been used by Stizenberger, 1861, for a genus of lichens.

Up to the present no teleomorph of the species of *Tubakia* is known, even if the sporadic presence of microconidia of *Tubakia dryina*, described for the first time by Yokoyama and Tubaki (1971) and later by Kim and Wagner (1977), Kobayashi et al. (1979), Glawe and Crane (1987), Holdenreider and Kowalski (1989) and also noted by the present author (Figs. 1-3), might suppose the existence of such a morph.

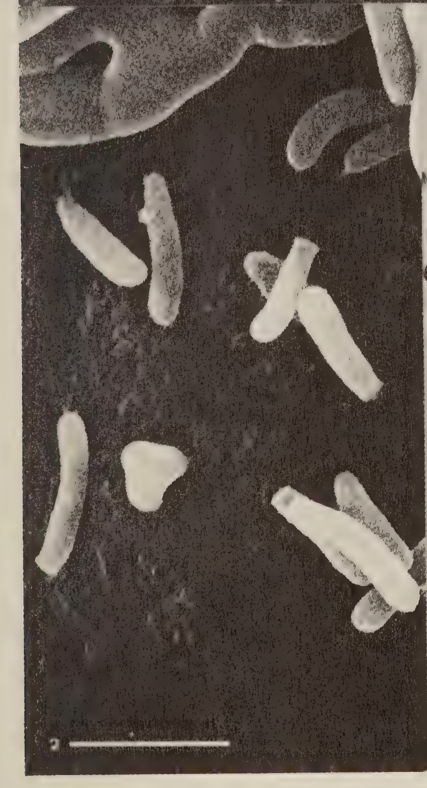
ANAMORPH - TELEOMORPH CONNECTION

At the end of February 1989, in the Grosseto farm nursery, an ascomycete belonging to the order Diaporthales was found, for the first time ever, on overwintered fallen leaves of red oak seedlings affected in the previous summer by a foliar disease caused by *Tubakia dryina* (Belisario 1990). This ascomycete was also recorded at the end of March 1990, in the Rome farm nursery, on overwintered fallen leaves on the ground beneath two-year seedlings of the same host. The protuberant perithecia (100-200 µm), single or aggregated, brownish to black, were present on both leaf surfaces, more frequently on the adaxial one.

Single ascospore cultures were obtained by crushing mature perithecia in sterile distilled water and sowing the resulting suspension of ascospores on water agar in petri dishes. Germinating ascospores were removed within 24 h and placed on carrot agar in petri dishes, in

Figs. 1-3. *Tubakia dryina*. 1. Two rhizothyria on leaf surface producing microconidia SEM X 750, scale = 10 µm. 2. Microconidia on leaf surface SEM X 5,000, scale = 5 µ. 3. Rhizothyrium with macro- and microconidia, scale = 115 µm.

1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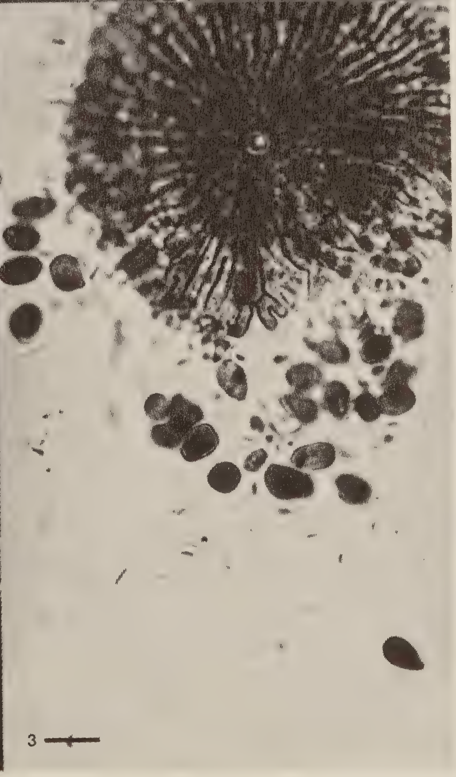
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thermostat at 25 ± 1 C, in darkness. Colonies grew rapidly in concentric circles, white at first then greyish brown with floccose white to pale fuscous aerial mycelium. Abundant sporodochium-like conidiomata were produced in no more than 7 da. No perithecia were formed in culture.

The comparison between cultures derived from single ascospores and the original cultures of *T. dryina* obtained from naturally infected tissue and from conidia, on the basis of macro- and microscopic characteristics, revealed no differences.

The connection between the diaporthaceous ascomycete and *T. dryina* was also proved with artificial infections, made with a conidial suspension derived from single ascospore cultures (2 x 10^5 conidia/ml), sprayed on one-year red oak seedlings during the vegetative season. The plants were then covered by single transparent plastic bags for 40 h. All the infections, which were repeated three times on ten plants for each treatment, showed full success in reproducing the typical symptoms of the foliar disease caused by *T. dryina*, accompanied also by the formation of abundant rhizothyria. Controls, sprayed with sterile distilled water, remained completely healthy.

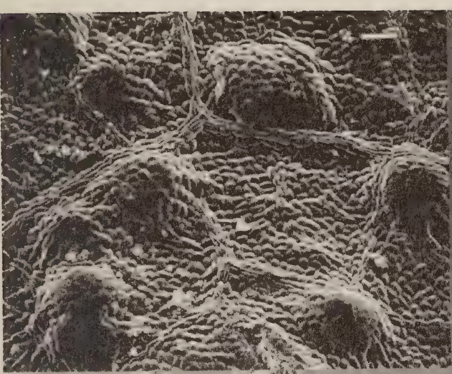
TELEOMORPH

Perithecia were removed from overwintered fallen leaves collected in different periods from the Grosseto farm nursery. Sections were made at 15 µm thickness with a freezing microtome. Each slide prepared held the complete vertical section of one or more perithecia. Horizontal sections were also made. Stains included methylene blue, congo red, anilin blue, light green (Johansen 1940). Ribbons were mounted on glass slides in glycerine or lactic acid. All the structures were measured in lactic acid.

Description:

Perithecia in overwintered fallen leaves (Fig. 4), separate or gregarious, brownish to black, immersed in host tissue, occupying, together with the stroma, the entire leaf thickness at maturity (Fig. 5), globose to

Figs. 4-9. *Dicarpella dryina*. 4. Protuberant perithecia in overwintered *Quercus rubra* leaf SEM X75, scale = 100 µm. 5. Nearly median longitudinal section of nearly mature perithecium in host tissue, sectioned at 15 µm, stained with congo red, scale = 43 µm. 6. Nearly mature perithecium median longitudinal section, occupying whole leaf thickness, scale = 23 µm. 7. Nearly mature ascus with ascospores, scale = 8.33 µm. 8. Finely ornamented ascospore wall SEM X7,500, scale = 1 µm. 9. Enlargement of ornamented ascospore SEM X20,000, scale = 1 µm.



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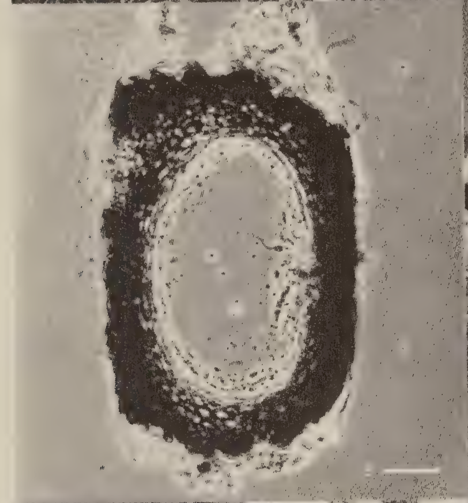

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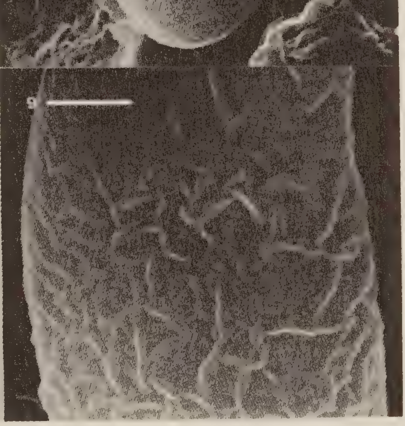
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slightly flattened, 193-262 µm diam, 220-291 µm high, sometimes oblique or horizontal; beak short, usually lateral or eccentric, slightly protuberant epiphyllously, rarely hypophyllously, 80-90 µm long, 15-20 µm wide near base, apex rounded; ostiole periphysate (Fig. 6), communicating with the cavity at maturity. Stromatic tissue of venter of perithecia 30-40 µm thick, of beak 40-50 µm thick, composed of several layers of pseudoparenchymatous dark, firm-walled, rounded or ellipsoid cells, 8.5-14.5 x 4.5-6.5 µm, peridium variable in thickness, composed of few layers of thin-walled, pallid, compressed cells, tightly connected with the stroma (Fig. 6). Asci unitunicate, eight spored, oblong to ellipsoid, 29-52.6 x 5.3-10.5 µm in spore-bearing part (Fig. 7), peripheral, frequently with stalk short or elongate up to 45 µm; ascus apex with two refractive conoid structures; asci deliquescing at maturity. Paraphyses lacking. Ascospores more or less uniseriate, becoming irregularly biseriate, 10-15.8 x 4.7-6.5 µm, one celled, hyaline, ellipsoid or fusoid, often inequilateral or slightly curved, wall finely ornamented (Figs. 8-9), contents granular guttulate.

For the above-mentioned characteristics, particularly for the perithecia with short beaks, all surrounded by a thick stroma and for the deliquescing asci, the fungus can be referred to the order Diaporthales. Among the species of this order the teleomorph has some similarities to *Sphaerognomonia carpinea* (Fr.) Potebnia with the short beak and the host range, but differs principally by forming larger perithecia completely surrounded by a thick stroma, by long-stalked asci, and by firm-walled ascospores. These features make it closer to the genus *Dicarpella* Sydow & Sydow, proposed by Sydow & Sydow (1920) in place of *Disperma* Theissen, which is composed of three species: the type species *D. bina* (Harkn.) Sydow & Sydow [synonymous with *Physalospora bina* Harkness and with *Disperma bina* (Harkn.) Theissen] on leaves of *Quercus agrifolia* Née, *D. georgiana* (Miller & Thompson) Barr on leaves and petioles of *Nyssa* and *Liquidambar* spp., and *D. quercifolia* (Ellis & Everh.) Barr (synonymous with *Physalospora quercifolia* Ellis & Everh.) on leaves of *Quercus agrifolia* (Barr 1978, 1979).

The teleomorph differs both from *D. bina* for its eight-spored asci and from *D. georgiana* for its distinctly smaller perithecia. Even if it is closer to *D. quercifolia* it differs both in size and shape of asci and ascospores (Table 1). The teleomorph does not fit any described species of *Dicarpella*. The material was examined together with M. E. Barr and we both agree that it is a previously undescribed species of *Dicarpella*.

Table 1 - Distinctive features of the species belonging to the genus *Dicarpella* Sydow & Sydow.

ASPECT (µm)	SPECIES			
	D. bina	*D. georgiana*	*D. quercifolia*	*D. dryina*
Perithecia diam. x high	200-220 x 230-260	350-550 x 260-440	250x330	193-262 x 220-291
Asci	(two spored) 42-55 x 11-16.5	(eight spored) 47-72 x 12-16	(eight spored) 75-80 x 12	(eight spored) 29-52.6 x 5.3-10.5
Stalk	-	-	-	up to 45
Ascospores	18.5-25 x 7.5-12	13-18 x 6-8	15-25 x 6-8	10-15.8 x 4.7-6.5
Host	*Quercus agrifolia* Née	*Nyssa* spp. *Liquidambar* spp.	*Quercus agrifolia* Née	*Quercus rubra* L.
Conidial state	Unknown	? *Harknessia americana* (Mont.) Sutton	? *Harknessia* sp.	*Tubakia dryina* (Sacc.) Sutton

Dicarpella dryina Belisario & Barr sp. nov. Figs. 4-9

Perithecia singularia vel aggregata in transhiemalibus foliis insidentia, globosa vel leniter applanata, 193-262 µm longa, 220-291 µm alta, aliquando obliqua vel horizontalia, tantum rostro eccentrico vel laterale, curto, compacto crasso, 80-90 µm alto, 15-20 µm lato ad basem, periphysato, ostiolato vix prominula; textura stromatica pseudoparenchymatica carbonacea, 30-40 µm lata, circa rostrum crassiore usque 40-50 µm, cellis pariete crassa, 8.5-14.5 x 4.5-6.5 µm, tota cincta. Peridium tenuibus pallidisque cellulis constitutum. Asci unitunicati, octospori, oblongi vel ellipsoidei, apice duobus conoideis structuris praediti, parte sporifera 29-52.6 x 5.3-10.5 µm, saepe in pedicello, usque 45 µm longo, attenuati, maturitate facile subhymenio separati et deliquescentes. Paraphyses nullae. Ascosporae uniseriatae vel irregulariter distichae, uniloculatae, hyalinae, acute ellipsoideae vel late fusiformae saepe inaequilateralae vel curvulae, 10-15.8 x 4.7-6.5 µm, pariete refractiva ornata, contento guttulato.
Status conidicus *Tubakia dryina* (Sacc.) Sutton.
Habitat: in transhiemalibus foliis dejectis *Quercus rubra* L. in Grossetano agro et prope Romam, Italiae centralis.
Holotypus: Belisario (ROHB)
Isotypus: In Agreste et Silvestri Experimantali Sede (SAF-Romae).

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NOMENCLATURE OF THE DOWNY MILDEW FUNGUS ON SPINACH

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Recent literature indicates confusion among scientists over the proper nomenclature of the downy mildew pathogen on spinach (Spinacia oleracea L.). For example, Goode *et al.* (8), Dainello *et al.* (3), and Inaba *et al.* (10) all referred to the downy mildew pathogen on spinach as *Peronospora effusa* (Grev. ex Desm.) Ces. Scheewe and Philipp (13) referred to it as *P. spinaciae* Laub., whereas Yerkes and Shaw (15) used the binomial and authorities *P. farinosa* (Fr.) Fr.

The pathogen causing downy mildew on spinach was first described by Greville (9) in 1824 as *Botrytis effusa*. Fries in 1832, however, did not list *B. effusa* Grev. in the *Systema Mycologicum*, but described *Botrytis farinosa* Fr. as a pathogen on one or more species of *Atriplex* within the Chenopodiaceae (12). In 1837, Desmazières (5) used the name *B. effusa* Grev. for a fungus found on *Chenopodium* spp. and *Atriplex* spp., and suggested that Fries' *B. farinosa* on *Atriplex* and Greville's *B. effusa* on spinach were the same organism. In 1849, Fries transferred *B. farinosa* to *Peronospora* (7). *Botrytis effusa* (Grev.) was transferred to *Peronospora* by Cesati in 1852 (12,14). In 1854, Rabenhorst (11) also used the combination *P. effusa* for the fungus on *Chenopodium*; spinach, however, was not listed as a host. In 1863, de Bary (4) used the binomial *P. effusa* (Grev.) Rabnh. and for many years mycologists followed this nomenclature.

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Caspary (2) established "major" and "minor" varieties for *Peronospora effusa* (Grev.) Rabnh., based on suspected morphological differences. Farlow (6) later described these differences between "major" and "minor" varieties as follows: Major - conidiophore tips thick, short, subulate (slender and tapering to a point), and reflexed with conidia being ellipsoid and distinctly pedicellate; Minor - conidiophores narrow, lower divisions suberect, tips subulate, erect, and slightly curved with condia globose - ovoid, not distinctly pedicellate.

In 1914, Wilson (14) reported that Keissler had transferred *B. farinosa* to *Peronospora* in 1911, but it had previously been transferred by Fries in 1849 as mentioned above. Wilson believed that the "major" and "minor" varieties established by Caspary for *P. effusa* should be raised to species rank and recognized the variety "major" as *P. effusa* (Grev.) Ces., with spinach as the major host and the variety "minor" as *P. farinosa* (Fr.) Keiss., with *Atriplex*, *Chenopodium* and spinach as hosts.

Gäumann (7) found that downy mildew isolates from 20 different species in the Chenopodiaceae could not be separated into the two species, *P. farinosa* and *P. effusa*, based on the branching of conidiophores or shape of the conidia. He measured 500 conidia and plotted a distribution curve for both the length and width of the conidia; from this study he established 14 different species.

Yerkes and Shaw (15) were unable to find any suitable morphological differences within the *Peronospora* complex on hosts in the Chenopodiaceae, and decided on a single species, *P. farinosa* (Fr.) Fr. for this pathogen. Although the name *P. effusa* predates *P. farinosa*, the latter was sanctioned by Fries and is therefore the correct name for the pathogen.

Byford (1) proposed the *formae speciales* designations "*spinaciae*" for the spinach pathogen, "*betae*" for the sugarbeet pathogen and "*chenopodii*" for the *Chenopodium* pathogen because previous studies had shown that these pathogens were host specific. The current name and authorities for the downy mildew pathogen on spinach, according to our interpretation of the rules of the Botanical Code, are *P. farinosa* (Fr.) Fr. f. sp. *spinaciae* Byford [= *P. effusa* (Grev.) Ces.].

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CONTRIBUTION TO A BIOGEOGRAPHICAL STUDY OF THE AUSTRO-AMERICAN XYLOPHILOUS POLYPORES (APHYLLOPHORALES) FROM SANTA CATARINA ISLAND, SC., BRAZIL.

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A long period of 100 years without collections of Aphyllophorales on the Island of Santa Catarina, Santa Catarina State, Brazil, and the absence of a mycological survey of this Island, prompted us to undertake a floristic study in this regard. The first mycological record on the Island was made by Adalberto de Chamisso in 1815, and the results were published by Ehrenberg in Nees von Essenbeck in 1820 (Fidalgo, 1968).

A later contribution was made by Léveillé (1846) when studying materials from the area at the Cryptogamic Herbarium of the Muséum d'Histoire Naturelle in Paris.

Fifty years later, Ernst Henrich Ule, upon moving in 1883 to Santa Catarina State, collected a total of 1650 fungus specimens. (The Aphyllophorales were published by Pazschke (1892) and Hennings (1897).

Another important contribution was that of Alfred Gustav Möller, who spent 20 months in Blumenau from 1890 to 1891. His collections, deposited in the Berlin Museum, together with others made in Brazil, were destroyed during World War II (Fidalgo, 1968). Möller's Aphyllophorales were published by Bresadola (1896).

An indirect contribution to our knowledge of the polypore flora of the State of Santa Catarina was made by Ryvarden (1973, 1976, 1977, 1981-1985, 1988a, 1988b, and 1989), Rajchenberg & Wright (1987), Rajchenberg (1987) and Rajchenberg & de Méijer (1990), while studying type specimens and otherwise of species described by Persoon, Klotzsch, Berkeley, Léveillé, Montagne, Bresadola, Patouillard, Murrill, Cooke, Lloyd Spegazzini and Rick. They showed that several species of tropical distribution (both neo- and pantropical) were based on Brazilian holotypes.

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[1] Partial results of a Ph.D. Thesis presented at the University of Buenos Aires, Argentina. Doctorate Fellow of CAPES/PICD, Brazil.

The Island of Santa Catarina

Located between 27° 10' and 27° 50' S latitude, and 48° 25' and 48° 35' W longitude, the Island covers a surface of 425 sq. km, with a broken coastline of 172 km, with numerous bays, inlets and cliffs, and zones of mangroves. Its localization, with the influence of maritime air, place it within a mesotherm-humid climate in Köppen's system, with rains uniformly distributed throughout the year, with hot summers (Caruso, 1983). If the atmospheric systems penetrating the region are considered, Strahler (1984) would place it in his Group I, with a medium latitude humid climate, between 0° and 30° S latitude, regulated by masses and frontal zones of predominantly tropical and equatorial air, in spite of the invasion of polar air. Thus, it can be considered from a biogeographical standpoint, as pertaining to the Neotropical region of the Amazonic Dominion in the Atlantic zone (Cabrera & Willink, 1973).

The present tendency in the taxonomy of Basidiomycotina is to correlate morphological, physyiological and ecological characteristics, principally based on Nobles' system (1971). She (Nobles, 1971) was the first to propose for the Aphyllophorales a general pattern that separates two large groups of xylophilous fungi: one, more primitive, with bipolar incompatibility, producing a brown rot and growing mainly on gymnosperms, and another, more "advanced", with tetrapolar incompatiblity, producing a white rot, and found mainly on angiosperms.

Materials and methods

The species included in this survey are deposited in herbarium **FLOR** (Holmgren & Keuken, 1974). Information on the known distribution of the species found on the Santa Catarina Island was taken from the literature.

Relationships of this mycoflora with that of NE Argentina (Parque Nacional Iguazú, Misiones Province), was deduced from the material preserved at **BAFC**, whereas those with East Africa and SE United States were taken from Ryvarden and Johansen (1980) and Gilbertson and Ryvarden (1986, 1987), respectively.

In the subsequent list of species the following abbreviations are used: **N** = neotropical; **P** = pantropical; **C** = cosmopolitan; **BR** = recorded for Brazil; **SC** = first record for Santa Catarina State, and * = previously recorded.

List of species

	Distribution	Record
GANODERMATACEAE		
Amauroderma omphalodes (Berk.)Torrend, Broteria Bot. **18**: 131. 1920.	**N**	**SC**
Ganoderma tornatum (Pers.)Bres., Hedwigia **53**: 55. 1912.	**P**	*

HYMENOCHAETACEAE

Coltricia spathulata (Hook.)Murr., N. Am. Fl. **9**: 93. 1908.	P	SC
Cyclomyces iodinus (Mont.)Pat., Essai Tax. p. 98. 1900.	N	SC
Inonotus patouillardii (Rick) Imaz., Bull. Tokyo Sci. Mus. **6**: 105. 1943.	P	SC
Phellinus apyahinus (Speg.) Rajch.& Wright, Mycologia **79** (2): 251. 1987.	N	SC
Phellinus callimorphus (Lév.)Ryv., Prel. Flora East Africa p. 145. 1980.	P	BR
Phellinus flavomarginatus (Murr.) Ryv., Norw. J. Bot. **19**: 234. 1972.	N	BR
Phellinus ferreus (Pers.) Bourd. & Galz., Hymen. France p. 627. 1928.	C	SC
Phellinus gilvoides (Petch)Ryv., Norw. J. Bot. **19**: 234. 1972.	P	BR
Phellinus gilvus (Schw.:Fr.)Pat., Essai Tax. p. 97. 1900	C	*
Phellinus punctatiformis (Murr.)Ryv., Norw. J. Bot. **19**: 235. 1972.	N	SC
Phellinus punctatus (Fr. ex Karst.)Pilát., Atlas Champ. Europe **3**: 530. 1942.	C	SC
Phellinus umbrinellus (Bres.) Herrera & Bond. Mikol. Fitopatol. **14** (1): 8. 1980.	P	*
Phellinus undulatus (Murr.)Ryv., Norw. J. Bot. **19**: 235. 1972.	N	BR
Phellinus wahlbergii (Fr.)Reid, Contr. Bolus Herb. **7**: 97. 1975.	P	BR
Phylloporia chrysita (Berk.)Ryv., Norw. J. Bot. **19**: 235. 1972.	P	SC

POLYPORACEAE

Amylosporus bracei (Murr.) David & Rajch., Mycotaxon **22** (2): 288. 1985.	N	BR
Antrodia albida (Fr.) Donk., Persoonia **4**: 339. 1966.	C	*
Antrodiella multipileata Leite & Wright n.sp.	N	
Antrodiella semisupina (Berk. & Curt.) Ryv., Prel. Pol. Flora East Africa, p. 261. 1980.	P	BR
Bjerkandera adusta (Willd.:Fr.) Karst., Medd. Soc. F. Flora Fenn. **5**: 38. 1879.	C	*
Ceriporia mellea (Berk. & Br.)Ryv., Bull. J. Bot. Nat. Belg. **48**: 98. 1978.	P	SC
Ceriporia xylostromatoides (Berk.) Ryv. & Johans., Prel. Pol. Flora East Africa, p. 276. 1980.	P	SC
Ceriporiopsis pannocincta (Rom.) Gilb. & Ryv., Mycotaxon **22**: 364. 1985.	C	BR
Coriolopsis rigida (Berk. & Mont.)Murr., N. Am. Fl. **9**: 75. 1908.	P	SC
Datronia scutellata (Schw.)Dom., Fungi, p. 181. 1973.	C	BR
Dichomitus anoectoporus (Berk. & Curt.) Ryv., Mycotaxon **20** (2): 331. 1984.	N	SC

Flaviporus liebmanni (Fr.)Ginns, Can. J. Bot. **58**: 1514. 1980.	P	*
Fomitella supina (Swartz.:Fr.)Murr., Bull. Torrey Bot. Club **32**: 365. 1905.	P	BR
Gloeophyllum striatum (Swartz.:Fr.)Murr., Bull. Torrey Bot. Club **32**: 370. 1905.	P	*
Gloeoporus dichrous (Fr.)Bres., Ann. Mycol. **14**: 230. 1916.	C	*
Gloeoporus thelephoroides (Hook.) G.H.Cunningh., Polyp. New Zealand, p. 111. 1965.	P	*
Hexagona hydnoides (Swartz.:Fr.) O.K.Fidalgo, Mem. N. Y. Bot. Gard. **17** (2): 64. 1968.	P	*
Hexagona papyracea Berk., Ann. Mag. Nat. Hist. **10**: 379-380. 1843.	P	*
Hexagona tenuis (Hook.)Fr., Epicr. Syst. Mycol., p. 498. 1838.	P	BR
Junghuhnia polycystidiata (Rick)Rajch., Nord. J. Bot. **7**: 566. 1987.	N	BR
Junghuhnia undigera (Berk.)Ryv., Mycotaxon **20**: 359. 1984.	P	SC
Junghuhnia vincta (Berk.)Hood & Dick., New Zeal. J. Bot. **26**: 114. 1988.	N	*
Megasporoporia cavernulosa (Berk.)Ryv., Mycotaxon **16**: 174. 1982.	P	SC
Microporellus dealbatus (Berk.& Curt.)Murr., Bull. Torrey Bot. Club **32**: 483. 1905.	P	SC
Nigroporus vinosus (Berk.)Murr., Bull. Torrey Bot. Club **32**: 361. 1905.	P	SC
Pachykytospora alabamae (Berk. & Cke.)Ryv., Norw. J. Bot. **19**: 233. 1972.	N	BR
Perenniporia ohiensis (Berk.)Ryv., Norw. J. Bot. **19**: 143. 1972.	N	BR
Perenniporia piperis (Rick) Rajch., Nord. J. Bot. **7**: 555. 1987.	N	SC
Perenniporia stipitata Ryv., Mycotaxon **28** (2): 535. 1987.	N	SC
Polyporus blanchettianus Berk. & Mont., Ann. Sci. Nat. III, **11**: 238. 1849.	P	*
Polyporus dictyopus Mont., Ann. Sci. Nat. II, **3**: 349. 1835.	P	BR
Polyporus guianensis Mont., Ann. Sci. Nat. II, **13**: 201. 1840.	N	SC
Polyporus leprieurii Mont., Ann. Sci. Nat. II, **13**: 203-204. 1840.	N	*
Polyporus tenuiculus Beauv.:Fr., Syst. Mycol. **1**: 344. 1821.	P	*
Polyporus tricholoma Mont., Ann. Sci. Nat. II, **8**: 365. 1857.	P	SC
Polyporus virgatus Berk. & Curt., J. Linn. Soc. **10**: 304. 1868.	P	*
Pseudofavolus cucullatus (Mont.) Pat., Essai Tax., p. 81. 1900.	P	BR
Pycnoporus sanguineus (L.:Fr.)Murr., Bull. Torrey Bot. Cl. **31**: 421. 1904.	P	*
Rigidoporus lineatus (Pers.)Ryv., Norw. J. Bot. **19**: 236. 1972.	P	BR

Schizopora flavipora (Berk. & Curt.)Ryv., Mycotaxon **23**: 186. 1985.	**P**	**BR**
Schizopora paradoxa (Fr.)Donk, Persoonia **5**: 76. 1967.	**C**	**SC**
Trametes cubensis (Mont.)Sacc., Sylloge Fungorum **9**: 198. 1891.	**N**	**SC**
Trametes elegans (Spreng.:Fr.)Fr., Epicr. Syst. Mycol., p. 492. 1838.	**P**	**SC**
Trametes socotrana Cke., Grevillea **11**: 39. 1882.	**P**	**BR**
Trametes versicolor (L.:Fr.)Pilát, Atl. Champ. Europe **3**: 261. 1936.	**C**	*
Trametes villosa (Fr.)Kreisel, Cienc. Biol. (Cuba), ser. 4, **16**: 84. 1971.	**N**	*
Trichaptum sector (Ehrenb.:Fr.)Kreisel, Cienc. Biol. (Cuba), ser. 4, **16**:84. 1971.	**N**	*
Tyromyces crassisporis Leite & Wright n. sp.	**N**	

Thus, the Island of Santa Catarina, from a mycological standpoint is tropical, and coincides in this regard with the general pattern established by Nobles (1971) and accepted by Watling (1982), who consider that brown-rot fungi are rare in the tropics, mostly recorded on conifers from the Northern hemisphere, whereas the white-rotting species grow on angiosperms in tropical latitudes. Ryvarden (pers. comm.) adds that in the Northern hemisphere approximately 20% of the polypores are brown rotters (North America and Northern Europe), while it is between 2-5% in the tropical areas (East and Central Africa).

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MYCOTAXON

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NEW SOUTH AMERICAN PILEATE POLYPORES (POLYPORACEAE) FROM SANTA CATARINA ISLAND, SC, BRAZIL.

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A survey of the wood-rotting fungi of Santa Catarina Island (27°10' and 27°30' S lat. and 48°25' and 48°35' W long.), Santa Catarina State (SC), Brazil, produced two undescribed species, Antrodiella multipileata and Tyromyces crassisporis.

Method

Microscopic examination of basidiomata was made from free-hand sections mounted in 5% KOH plus 1% aqueous phloxine, Melzer's reagent (Singer, 1962) and in 0.5% cotton-blue in 25% lactophenol. Drawings were made with the aid of a camera lucida. Colours are those of Munsell (1954). The herbarium materials studied are housed in **BAFC** (Argentina) and **FLOR** (Brazil). Herbarium designations are those of Holmgren and Keuken (1974).

Antrodiella multipileata sp. nov. (Fig. 1)

Basidiocarpo annuo, effuso-reflexo vel pileato, albo vel cremeo, non xanthochrous, poris 2-6-(7) per mm.

Systema hypharum dimiticum. Hyphis generativis fibulatis, parietibus angustis vel incrassatis, pallido luteis, 1.8-5.0 µm diam. Hyphis skeletibus 2.5-5.8 um diam., parietis incrassatis, luteis. Cystidiis adsunt. Basidiis claviformibus, tetrasporis, 12.6-15.1 x 2.9-3.6 µm. Bsidiosporis late ellipsoideis hyalinis, parietibus angustis, laevis, 3.6-4.7-(5) x 2.1-2.5-(2.9) µm, inamyloideis. Putrefactione ligno alba. Holotypus: Brasil, Santa Catarina, Ilha de Santa Catarina, Morro Lagoa da Conceiçao, leg. Loguercio Leite & Furlani n° 251, 26.VII.1988, in Herb. FLOR n° 10.633 conservatus est; Isotypus BAFC.

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[1] Partial resultas of a Ph.D thesis presented to the University of Buenos Aires, Argentina. Doctorate Fellow of CAPES/PICD, Brazil.

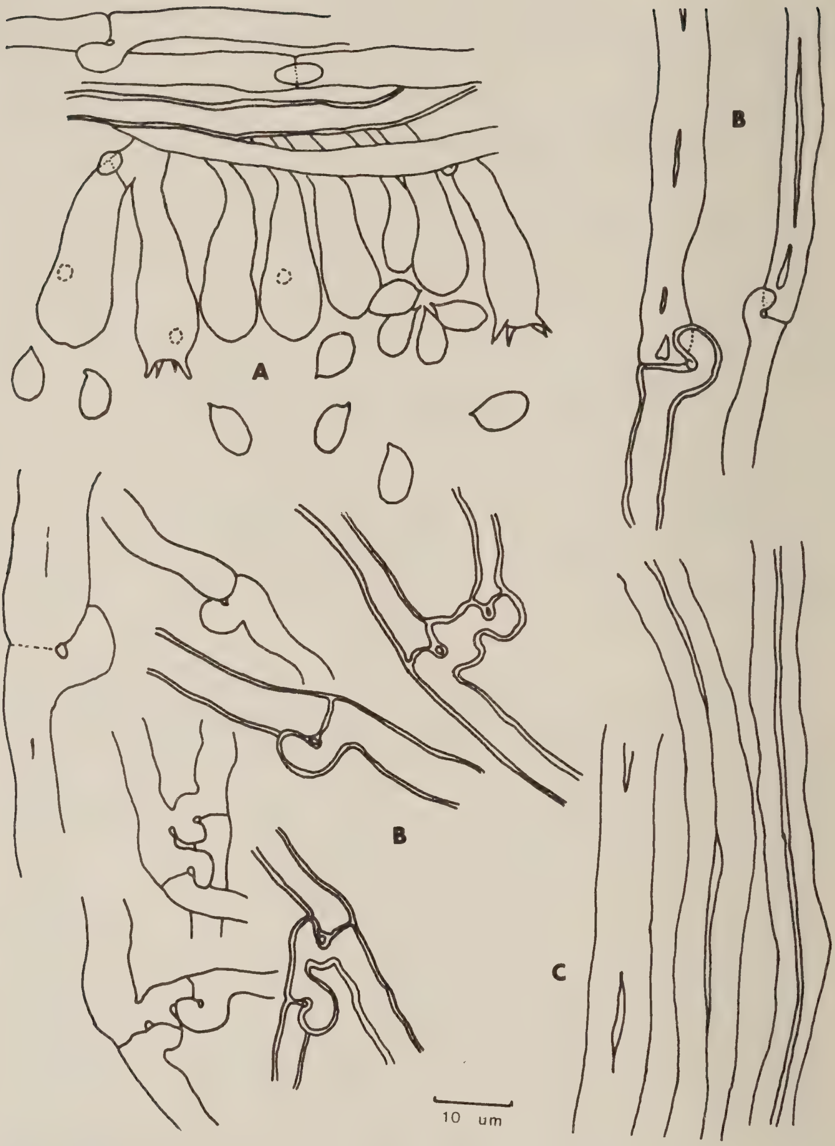

Fig. 1. **Antrodiella multipileata** n. sp. **a**: hymenium with basidia and basidiospores; **b**: Generative hyphae with clamps (in trama and context); **c**: skeletal hyphae.

Fruitbody annual, effused-reflexed to pileate; pileus broadly attached, dimidiate, solitary or imbricate up to 2.0 cm wide and 1-2 cm thick. Pilear surface white (10 YR 8/2) in fresh specimens, to cream (10 YR 8/3-8/4) when dry, zonate, somewhat radially wrinkled; margin thin, entire. Pore surface white (10 YR 8/2), yellow (10 YR 8/6), to brownish yellow (10 YR 6/6); pores irregular to angular, 2-6-(7) per mm, on the decurrent part of the basidiome split and then longer; margin poroid to irpicoid; tubes unistratified, concolorous with the pore surface, 0.5-1.5 mm thick; context thin, fibrous, dense, concolorous with the tubes, up to 0.5 mm thick.

Hyphal system dimitic: generative hyphae with clamps, hyaline, thin-walled in the trama, (1.8)-2.2-2.6 µm diam., thick-walled in the context, 3.6-5.1 µm diam.; skeletal hyphae hyaline, thick-walled to solid, straight to sinuous, 2.5-5 µm diam. in the trama, 4.3-5.7 µm thick in the context. Cystidia and other sterile elements absent. Basidia claviform, hyaline, thin-walled, 4-sterigmatous, 12.6-15.1 x 2.9-3.6 µm. Basidiospores broadly ellipsoid, hyaline, thin-walled, inamyloid, indextrinoid, 3.6-4.7-(5.1) x 2.2-2.5-(2.9) µm.

Habitat: on unidentified angiosperm and associated with a white rot.

Distribution: neotropical. Brazil: Santa Catarina and Paraná States.

Material examined: BRAZIL: Santa Catarina, Sta. Catarina Island, Morro Lagoa da Conceiçao, leg. Loguercio Leite & Furlani, nos 195, 223, 251; 26.VII.1988 (FLOR nos. 10601, 10618, 10633-Holotype, respectively. Paraná State: General Carneiro, Fazenda San Pedro, leg. A. de Méijer n° 1288, 8.VI.1989 (BAFC); ibid., leg. ipse n° 1382, 4.X. 1989 (BAFC); ibid., Curitiba, leg. ipse n° 752, 15.II.1987 (BAFC n° 31.276).

Remarks: Hyphal system, spore shape and white rot point to Antrodiella Ryv. & Johans. The reason for the new species is the correlation of an irpiciform hymenial configuration, the colour of the pore surface, the context and the tubes, the broadly ellipsoid spores, larger (3.6-5.1 x 2.1-2.9 µm) than those of other species, viz. A. minutispora (Reid) Ryv. and A. semisupina (Berk. & Curt.) Ryv. (Ryvarden & Johansen, 1980; Gilbertson & Ryvarden, 1986). A thorough search among the species of irpicoid polypores listed by Rick (1959), Maas Geesteranus (1974) and Corner (1987) did not reveal any that could match the present one. However, Cunningham's interpretation of Irpex zonatum Berk., judging from materials so determined in PDD, comes very close to our species, differing in having narrower skeletal hyphae and exhibiting conspicuous leptocystidia. An investigation of the I. zonatum-consors complex, which ought to include culture features, seems desirable.

Tyromyces crassisporis n. sp.

Basidiocarpo zonato, effuso-reflexo vel cupuliforme, pendulo. Pileo solitario vel lateraliter connato; facies abhymenialis ad substrato umbonato. Superficie pileo alba, gossypina vel myceliosa; poris cremeis, angularibus, 5-7 per mm, vel longitudinaliter elongatis obliquis, dissepimentis angustis integerrimis vel leviter dentatis, cereis vel fragilissimis in sicco, facile secedentibus.

Systema hypharum monomiticum, hyphae generativae hyalinae, ramificatae tenuitunicatis, 1.8-2.5 µm diam. vel leviter incrassatis, 2.1-2.5 µm diam. vel irregulariter incrassatis, 2.1-2.8 µm diam. Cystidiis

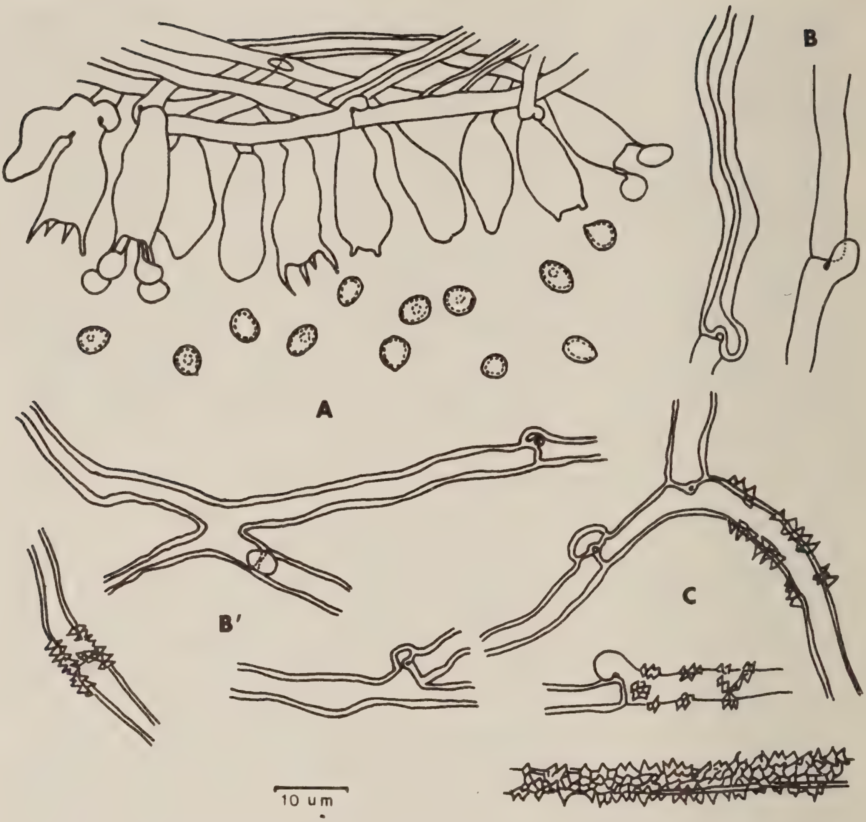

Fig. 2. **a**: hymenium and basidiospores; **b**) thin- and thick-walled generative hyphae; **b'**) typical clamped thick-walled generative hyphae; **c**) incrusted hyphae.

adsunt. Basidiis claviformibus, hyalinis, cum fibula basali, 8.6-9.0-(9.7) x 3.6-4.7 µm. Basidiosporis ovoideis, globosis, hyalinis, crassitunicatis, 2.1-2.5 x 1.8-2.1 µm, inamyloideis, acyanophilis. Putrefactione ligno alba. Holotypus: Brasil, Santa Catarina, Ilha de Santa Catarina, Morro da Lagoa de Conceiçao, leg. Loguercio Leite & Furlani n° 419, 11.II.1989 in Herb. **FLOR** n° 10.731 conservatus est.

Fruitbody annual, effused-reflexed to cupuliform, pendent. Pileus solitarysolitary to laterally connate, one face laterally attached by an umbo, abbreviated or broad, 2-5 mm diam. x 1-3 mm high in cup-shaped specimens, and 2-4 mm in effuse-reflexed ones. Pilear surface white (10 YR 8/1), cottony, margin gossypine; in effused-reflexed specimens margin mycelial. Pore surface cream (10 YR 8/3), pores angular, 5-7 per mm, to elongated in vertical substrates; dissepiments thin, entire to slightly dentate; tubes concolorous with hymenial surface, up to 0.5 mm thick, waxy and crumbly in dry specimens, easily separable from the context; context thin, fibrous, compact, white (10 YR 8/1), up to 0.2 mm thick.

Hyphael system monomitic: generative hyphae with clamps, branched, thin-walled, 1.8-2.5 µm diam., slightly thick-walled, 2.1-2.5 µm diam. in the trama; in the context irregularly thick-walled, 2.1-2.8 µm diam IKI-. Pilear surface of entangled generative hyphae with superficial crystals, IKI-. Cystidia and other sterile elements absent. Basidia claviform, thin-walled, hyaline, 4-sterigmate, with basal clamp connections, 8.6-9.0-(9.7) x 3.6-4.7 µm. Basidiospores ovoid to globose, hyaline, smooth, thin-walled, 2.2-2.5 x 1.8-2.2 µm, IKI-, acyanophilous.

Habitat: on unidentified angiospermous wood and associated with a white rot.

Distribution: neotropical; Brazil: Santa Catarina Island, Santa Catarina State.

Material examined: BRAZIL: Santa Catarina State, Santa Catarina Island, leg. Loguercio Leite & Furlani nº 419, 11.II.1989 (**FLOR** nº 10.731, HOLOTYPE).

Remarks: This species is included in *Tyromyces* Karst. because of its pileate and white basidiome and monomitic hyphal systema. *Tyromyces crassisporis* differs from other species of the genus by its thick-walled spores, cupuliform, pendent basidiome and waxy and crumbly consistency of the tubes (for characteristic of other species see Lowe, 1975; Gilbertson & Ryvarden, 1987; David & Duhem, 1986). The pointed crystals on the hyphae resemble those of *Skeletocutis* Kotl. & Pouz. (David, 1982; Keller, 1979). However, we feel convinced that the species should be placed in *Tyromyces* with its monomitic hyphal system.

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MYCOTAXON

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NEOTYPIFICATION OF **TRICHOSPORON BEIGELII**: MORPHOLOGICAL, PATHOLOGICAL AND TAXONOMIC CONSIDERATIONS

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INTRODUCTION

Most mycologists recognize the taxon *Trichosporon beigelii* (Kuchenmeister & Rabenhorst) Vuillemin 1902 as the type species of the anamorphic genus *Trichosporon* (Barnett et al., King & Jong, Langeron, Rippon). *T. beigelii* has many synonyms; Barnett et al. list 92. Other taxonomists prefer the name *Trichosporon cutaneum* (deBeurmann, Gougerot & Vaucher) Ota 1928 for nomenclatural reasons (Diddens & Lodder, Lodder & Kreger-vanRij, Kreger-vanRij). A minority of workers maintain the two taxa as separate species due to perceived differences in morphology or host pathology (Emmons et al.).

Both species were initially described as causes of human disease-- *T. beigelii* from white piedra (a superficial infection of hair shafts), and *T. cutaneum* from deep gummatous skin lesions. Since then, both taxa have been reported as normal skin flora and ubiquitous environmental saprophytes (Rippon).

A careful examination of type specimens would aid in resolving the identities of *T. beigelii* and *T. cutaneum*. Unfortunately, the holotype of *T. beigelii* cannot be located. It is not listed among available Rabenhorst exsicatta (Kohlmeyer, 1962a). The specimen may have been destroyed in a 1943 bombing of the Berlin-Dahlem herbarium (Kohlmeyer, 1962b). The Berlin-Dahlem curator confirmed its absence (B. Hein, personal communication). Similarly, none of Vuillemin's specimens in the Nancy herbarium survive (P. Valck, curator at Nancy, personal communication). Neither the United State Fungus Collections nor the Commonwealth Mycological Institute possess any types (A. Rossman and B. Sutton, respective personal communications).

MATERIALS AND METHODS

In the absence of available types, we compared two living cultures--*T. cutanum* from the urine of an immunosuppressed patient in Chicago (see McPartland); *T. beigelii* from the American Type Culture Collection (ATCC). Hereafter, the isolates are designated C#1650 and ATCC #28592, respectively. Both cultures were incubated at 23, 30 and 37ºC on Sabouraud's glucose agar, cornmeal agar, and potato-dextrose agar. We utilized the API 20C clinical yeast system (Ayerst Laboratories, Plainview, NY) to assess carbon and nitrogen assimilation. Cultures were exposed to *o*-dianisidine, a chemical reagent used for separating basidiomycetous yeasts from ascomycetous yeasts (van der Walt & Hopsu-Havu).

Isolates were examined under light microscopy as 1% KOH squash mounts or sectioned 0.5um thick and stained with toluidine blue. Only ATCC#28592 was prepared for transmission electron microscopy (TEM): Agar plugs were fixed in 2.5% glutaraldehyde in 0.1M cacodylate buffer and post-fixed in 1.5% OsO4 in 0.1M cacodylate. Following dehydration in a graded ethanol series and propylene oxide, cells were embedded in a mixture of EMbed 812/Araldite 502 and polymerized at 60ºC. Thin sections were stained with aqueous uranyl acetate and examined in a Phillips 300 TEM.

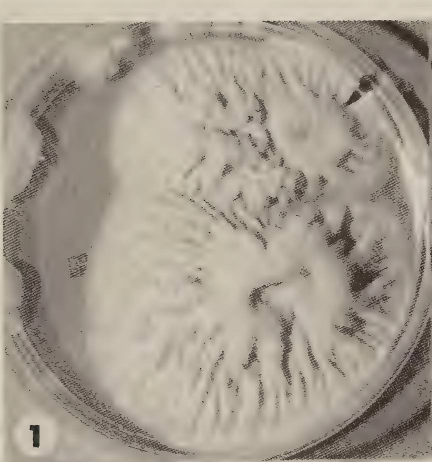
RESULTS

Both cultures grow quickly on Sabouraud's glucose agar and cornmeal agar, equally slower on potato-dextrose agar. Colony morphology is identical: off-white to cream-colored colonies with raised centers, developing a wrinkled surface with radially-oriented furrows (Fig. **1**).

ATCC #28592 only grows at 23 and 30ºC, whereas C#1650 grows at 23, 30 and 37ºC. When exposed to *o*-dianisidine, both specimens turn a dark red color, indicating basidiomycetous affinities. Both cultures lack the ability to ferment carbohydrates. They assimilate glucose, galactose, 2-keto-D-gluconate, L-arabinose, methyl-D-glucoside, N-acetyl-D-glucosamine, cellobiose, lactose, maltose, melezitose, raffinose, sucrose, trehalose and xylose. Reactions on glycerol, adonitol, xylitol, inositol and sorbitol are equivocal.

On Sabouraud's glucose agar, both ATCC #28592 and C#1650 produce arthroconidia and blastoconidia characteristic of the genus *Tricho-*

Figures 1–6. ***Trichosporon beigelii:*** **1.** Colony morphology of type culture, x0.75. **2.** Arthroconidia in KOH, LM, x2150. **3.** Arthroconidia and blastoconidia stained with toluidine blue, LM, x2150. **4.** Blastoconidium, TEM, x9500. **5.** Tip of hypha and blastoconidium enveloped in mucilagenous capsules, TEM, x7600. **6.** Dolipore septum in hypha, TEM, x36,100.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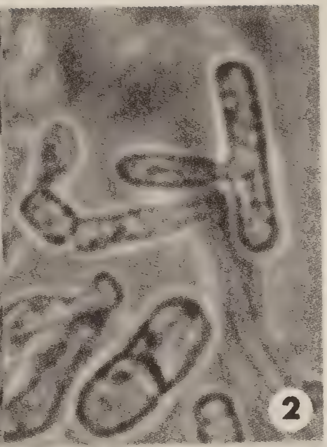
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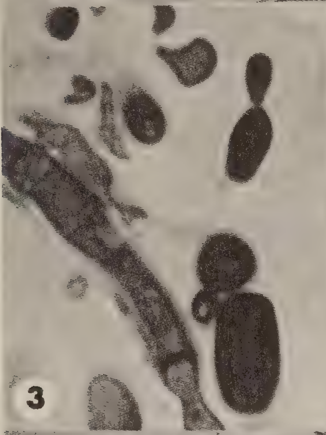
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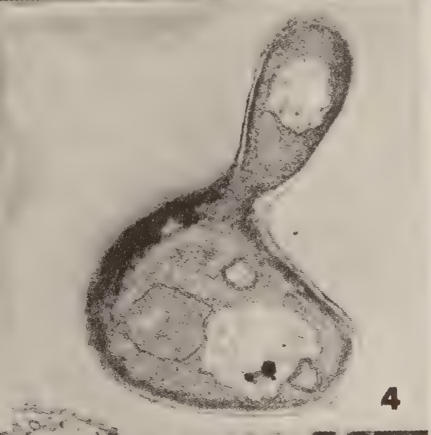
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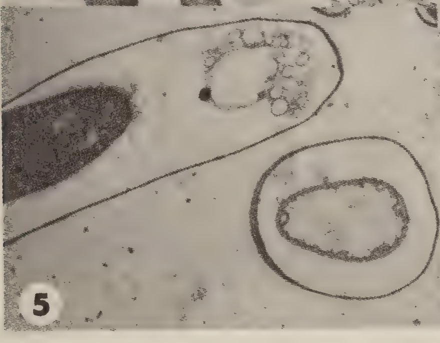
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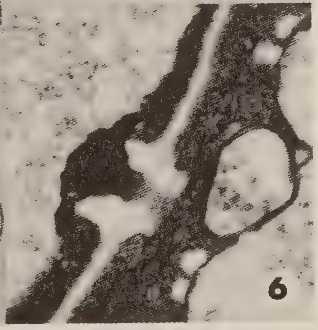
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sporon. Morphologically, ATCC #28592 and C#1650 are indistinguishable. Arthroconidia are quadrangular to long-cylindrical in shape, averaging 3-4 x 3-12 um (Fig. **2**,**3**). Blastoconidia bud from a narrow or broad base and become globose to pear-shaped, averaging 2-4 x 2-6 um (Fig. **3**,**4**). Septa observed under TEM exhibit a doliiform flare around the septal pore, morphology consistent with dolipore septa seen in dikaryotic basidiomycetes (Fig. **6**).

DISCUSSION

The original descriptions of *T. beigelii* and *T. cutanum* are located in obscure sources, often incorrectly cited by subsequent workers. *T. beigelii* was originally named *Pleurococcus beigelii* by Küchenmeister & Rabenhorst *in* Rabenhorst, Hedwigia **4**:49, 1867 (*not* Hedwigia **6**:49, apud Dodge). They received material from Beigel, who thereafter published illustrations of the fungus in 1869 (*not* antecedent 1865, apud Rippon).

Vuillemin found a similar fungus in France and accepted Küchenmeister & Rabenhorst's priority. He correctly transferred *P. beigelii* to the genus *Trichosporon*.

In 1909, deBeurmann, Gougerot & Vaucher described *Oidium cutaneum* in deBeurmann & Gougerot, Bull. Mem. Soc. Med. Hop., Paris **28**:256. King & Jong have previously noted citation errors published by Diddens & Lodder, Lodder & Kreger-vanRij and Carmo-Sousa. King & Jong also notice deBeurmann, Gougerot & Vaucher re-described *O. cutaneum* in Bull. Mem. Soc. Med. Hop., Paris **30**:938 (1910) without mentioning their prior publication. Ota transferred *O. cutaneum* to the genus *Trichosporon*.

Puntoni was the first to suggest that *T. cutaneum* may be a synonym of *T. beigelii*. Contrarily, Diddens & Lodder considered Küchenmeister & Rabenhorst's description inadequate and rejected *T. beigelii* as a "nomen dubium." They chose *T. cutaneum* as type species for the genus *Trichosporon*.

One of us (J.M.) translates Küchenmeister & Rabenhorst's Latin description as: "*Pleurococcus* aerial, minute, hyaline or light green in color; cells globose or angular, massing together in numerous groups which encircle and surround hairs, supported by a firm gelatinous mucilage; cell walls somewhat thick, hyaline, somewhat homogeneous; cell cytoplasm finely granulated; sporangia frequently 1/103 mill. thick, holding 12-20 gonidia with round nuclei. Cell diameter 1/287-1/222 millim."

Küchenmeister & Rabenhorst considered *P. beigelii* an alga and confused either arthroconidia or chlamydospores as "sporangiis." Regardless, their citation stands nomenclaturally correct and adequately describes the species in question. If doubts remain, one should consult illustrations of *T. beigelii* supplied by Beigel (Fig. **7**). Beigel may have been working with a mixed culture. *T. beigelii* cells are surrounded by mucilage (interpreted by Vuillemin as "gelification of the outer layer of the cell wall", see Fig. 5). Emmons et al. explain, "The capsule makes it difficult to isolate the fungus in pure culture..." Since deBeurmann, Gougerot & Vaucher erroneously described *T. cutaneum* fermenting glucose, they worked with a mixed culture as well.

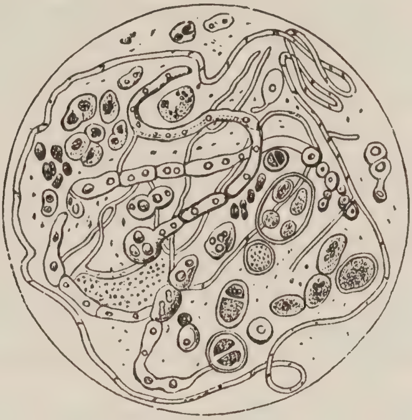

Figure 7. *Pleurococcus beigelii*, illustration by Beigel, 1869. (reduced from original, x0.88)

Langeron (1943) quickly criticized Diddens & Lodder's rejection of *T. beigelii* as "une bizarrerie de la nomenclature." Nevertheless, this opinion has been perpetuated by patrilineal citations (e.g., Diddens & Lodder, Lodder & Kreger-vanRij, Kreger-vanRij). Current researchers chosing to use *T. cutaneum* over *T. beigelii* often cite Kreger-vanRij as their authority (see Yoshida et al., Glumoff et al.).

Carmo-Sousa recognizes the priority of *T. beigelii* over *T. cutanum* but retains usage of the latter due to a misapplication of nomenclatural priority. King & Jong solve Carmo-Sousa's "puzzle" via Article 11.3 of the International Code of Botanical Nomenclature (ICBN).

Maintaining *T. cutaneum* and *T. beigelii* as different organisms due to differences in pathogenicity is untenable. Ecological characteristics are not an accepted criterion for separation of species. A superficial hair-infecting fungus may act as an invasive organism in an immunosuppressed host. It does not transform into another species during this process.

No type specimens of *T. beigelii* exist. Carmo-Sousa designates ATCC *28592 (the strain used in this study), as the "type culture" of *T. beigelii*. However, Article 9.5 of the ICBN clearly stipulates that nomenclatural types cannot be living cultures (Greuter).

In the absence of a holotype or lectotype of *T. beigelii*, a neotype should be designated. A dried preparation of ATCC *28592 may serve as a suitable neotype. We air-dried the culture plate illustrated in Figure 1 and deposited it at BPI (National Fungus Collections, Beltsville, Maryland, U.S.A.), accession number 1102616. Iso-neotypes were sent to herb. B (Berlin-Dahlem) and NYC (Nancy).

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DEMATIACEOUS HYPHOMYCETES ON FREYCINETIA (PANDANACEAE). 1. STACHYBOTRYS

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Abstract

Three new species of *Stachybotrys* are described and figured, *S. breviusculus* from New Caledonia and New Zealand, *S. freycinetiae* from New Zealand, and *S. nephrodes* from Samoa. In addition, *S. parvispora* Hansford from Cook Islands, New Caledonia, and Solomon Islands is described and figured. These fungi were found during a study of dematiaceous hyphomycetes on dead leaves of *Freycinetia* spp.

Introduction

There are 150-200 species of *Freycinetia* Gaudich., one of the three genera in the Pandanaceae, distributed from Sri Lanka, throughout South-East Asia and Malesia to Taiwan, New Zealand, and the Pacific islands in the east (Willis 1973, Mabberley 1987). Towards its geographical limits in the east and south of the Pacific, there is often only a single species in each island nation. For example, in New Zealand there is only *Freycinetia baueriana* Endl. ssp. *banksii* (Cunn.) Stone, with the other subspecies, *baueriana*, endemic to Norfolk Island. In the Cook Islands there is one species, *F. wilderi* Mart., and in Hawaii, *F. arborea* Gaud. Stems of *Freycinetia* are usually scrambling or climbing with adhesive roots, often with senescent, strap-like leaves still attached. Some indigenous peoples use the green leaves for weaving mats, baskets, skirts, etc. Stems and aerial roots are used as close-fitting coverings for implements, for making fish traps, and for tying thatch on house roofs. Many species have edible flowers or edible leafy flower bracts.

In the present study dead leaves were collected and examined for dematiaceous hyphomycetes. A total of 62 leaf samples were examined from eight countries, as follows: American Samoa (4 collections of *Freycinetia* spp.), Cook Islands (5 - of *F. wilderi*), Hawaii (1 - of *F. arborea*), Indonesia (1 - of *Freycinetia* sp.), New Caledonia (4 - of *Freycinetia* spp.), New Zealand (39 - of *F. baueriana* ssp. *banksii*), Solomon Islands (4 - of *Freycinetia* spp.), and Western Samoa (4 - of *Freycinetia* spp.). All fungal specimens are deposited in the herbarium of DSIR Plant Protection (PDD).

Many species of dematiaceous hyphomycetes have been found, and will be described in this and subsequent papers.

THE SPECIES - STACHYBOTRYS

Stachybotrys Cda produces single-celled conidia aggregated in slimy heads. In mass the conidia usually appear dark coloured. The phialidic conidiogenous cells and the conidiophores are often lighter. The genus is worldwide in distribution although some species are restricted to the tropics and subtropics. *Stachybotrys* species are common in soil and on decaying plant material. Jong & Davis (1976) reviewed the genus, especially those species for which living cultures were available. They treated 11 species, placing many other names in synonymy. Since 1976, at least 12 new species have been described.

Four species were found on *Freycinetia* leaves. *S. parvispora* Hansford, which occurs on other hosts in the tropics, was found in Cook Islands, New Caledonia, and Solomon Islands. *S. nephrodes* sp. nov. was found in Samoa and Solomon Islands; in Western Samoa it was also present on dead leaves of *Pandanus* sp. *S. breviusculus* sp. nov. was found in New Caledonia and New Zealand, while *S. freycinetiae* sp. nov. was common in New Zealand. *S. parvispora, S. breviusculus,* and *S. freycinetiae* form a series, with increasing size of conidia. They differ in conidial dimensions, phialide size, and conidiophore colour from similar species such as *S. mangiferae* Misra & Srivastava or *S. kampalensis* Hansford. The conidial shape of *S. nephrodes* is very distinctive, with the conidia tightly curled, quite unlike the other reniform species - *S. nephrospora* Hansford (= *S. reniformis* Tubaki, = *S. sinuatophora* Matsushima), *S. oenanthes* M.B. Ellis, and *S. renispora* Misra.

Stachybotrys breviusculus McKenzie sp. nov. Fig. 1

Mycelium internum. Conidiophora macronematosa, mononematosa, solitaria vel fasciculata, ramosa, erecta, recta vel paulo flexuosa, laevia vel interdum apicaliter verrucosa, septata, hyalina, usque ad 130 μm longa, basi 3.25-8.5 μm, prope apicem 2.5-3.5 μm, apice inflata 3-4 μm diam. Cellulae conidiogenae monophialidicae, discretae, 5-11 in verticillo dispositae, ellipsoidae 8.5-12 x 3.5-5 μm, hyalinae vel pallide straminea. Conidia in massis globosis aggregata, acrogena, cylindrica vel ellipsoidea, obscure olivaceo-grisea, laevia vel verrucosa, eseptata, (6.5-) 7-9 (-9.5) x (2-) 2.25-3 (-3.5) μm; apice rotundata, basi rotundata vel truncata.

In foliis mortuis pandanacearum *Freycinetia baueriana* ssp. *banksii* et *Freycinetia* sp.
Holotypus PDD 57594.

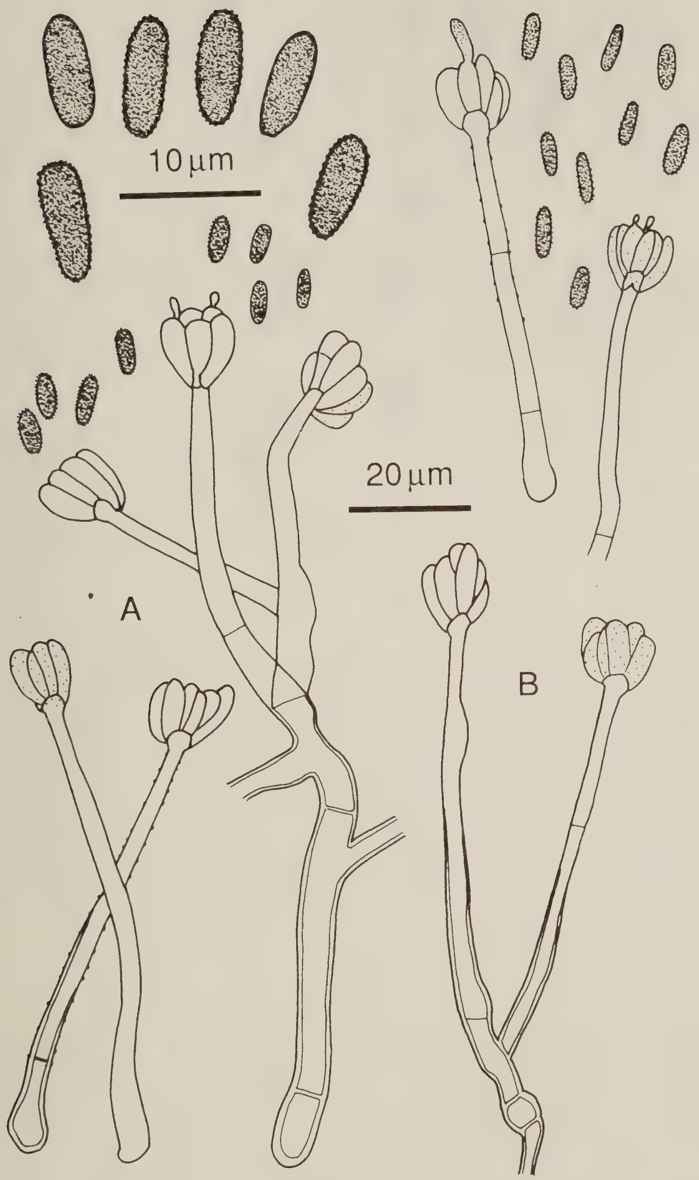

Figure 1. *Stachybotrys breviusculus*, conidiophores and conidia from host (A, PDD 57594, type; B, PDD 57596). Specimens mounted in hydrous lactophenol.

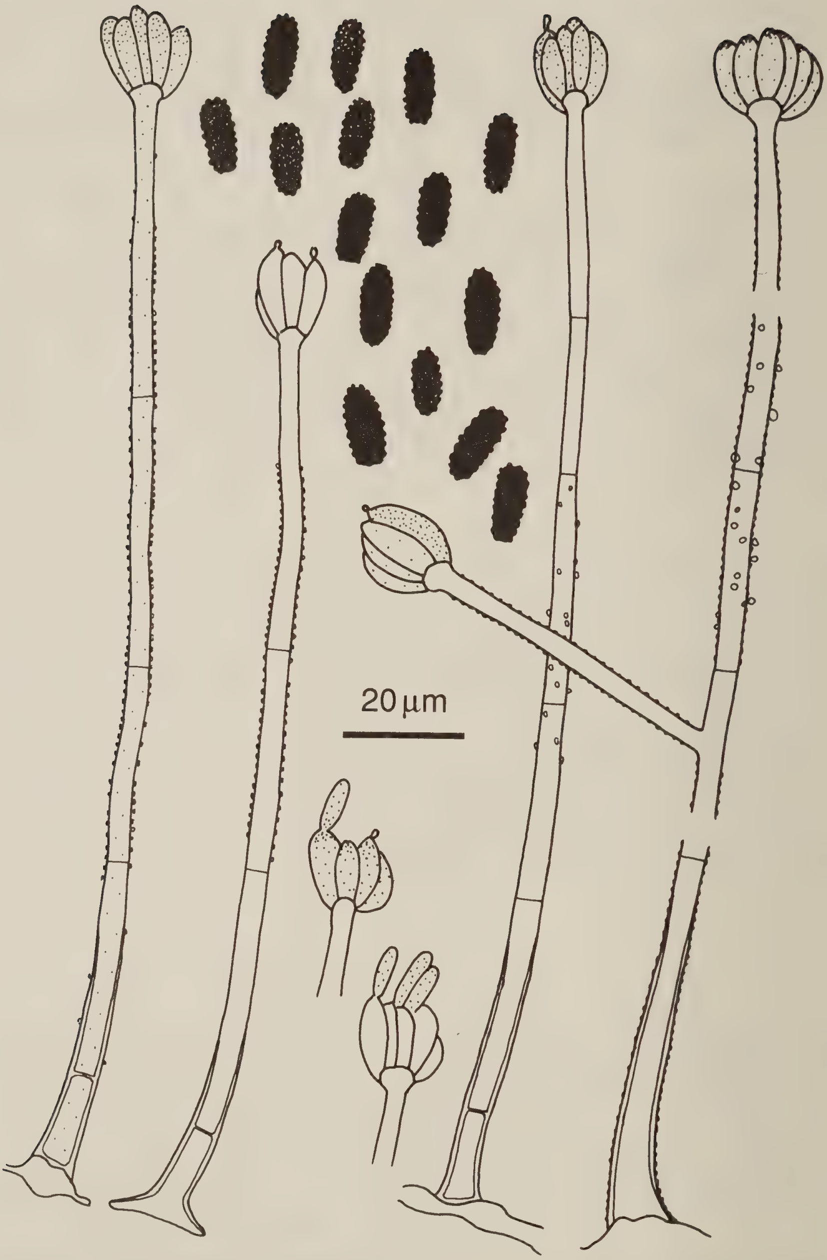

Figure 2. *Stachybotrys freycinetiae*, conidiophores and conidia from host (PDD 57639, type). Specimen mounted in hydrous lactophenol.

Mycelium immersed. Conidiophores macronematous, mononematous, single or in groups, branched, erect, straight or slightly flexuous, smooth or sometimes verrucose in upper part, septate, hyaline, up to 130 µm long x 3.25-8.5 µm thick at base tapering to 2.5-3.5 µm near the apex, slightly enlarged at the apex to 3-4 µm thick and bearing a whorl of 5-11 phialides. Conidiogenous cells monophialidic, discrete, terminal, ellipsoidal, 8.5-12 x 3.5-5 µm, hyaline or pale straw-coloured. Conidia aggregated in slimy, black, glistening heads, acrogenous, cylindrical or ellipsoidal, apex rounded, base rounded or truncate, dark olivaceous-grey, smooth or verrucose, non-septate, (6.5-) 7-9 (-9.5) x (2-) 2.25-3 (-3.5) µm.

On *Freycinetia baueriana* ssp. *banksii*
Specimens examined: **New Zealand**, NORTHLAND, Waipoua Forest, Yakas Kauri Track, 14.V.1986, P.K. Buchanan (PDD 59597); Puketi, 23.X.1987, E.H.C. McKenzie & P.R. Johnston (PDD 57594 - **holotype**). WAIKATO, near Kawhia, Te Kauri Reserve, 20.V.1988, E.H.C. McKenzie (PDD 57595).

On *Freycinetia* sp.
Specimen examined: **New Caledonia**, Mt des Koghis, 15.XI.1987, E.H.C. McKenzie (PDD 57596).

The specific epithet refers to the conidia of this species being somewhat shorter than those of *S. freycinetiae*.

Stachybotrys freycinetiae McKenzie sp. nov. Fig. 2

Mycelium partim internum et externum. Conidiophora macronematosa, mononematosa, solitaria vel fasciculata, interdum ramosa, erecta, recta vel paulo flexuosa, laevia vel verrucosa, interdum granulis magnis tecta, septata, hyalina vel pallide straminea, usque ad 320 µm longa, basi 5.5-8.5 µm, prope apicem 3-4.5 µm, apice inflata 4-5 µm diam. Cellulae conidiogenae monophialidicae, discretae, 7-9 in verticillo dispositae, clavatae, 10-14 x 4-5.25 µm, hyalinae, pallide straminea vel pallide brunnea. Conidia in massis globosis aggregata, acrogena, cylindrica, nigra vel atro-brunnea, maxime verrucosa, eseptata, (10-) 11-13 (-15) x (3.5-) 4-4.5 (-5.25) µm; apice rotundata, basi rotundata vel truncata.

In foliis mortuis pandanaceae *Freycinetia baueriana* ssp. *banksii*
Holotypus PDD 57639.

Mycelium partly superficial, partly immersed. Conidiophores macronematous, mononematous, single or in groups, sometimes branched, erect, straight or slightly flexuous, smooth or verrucose over all or part of the length, sometimes covered with large granules, septate, hyaline or pale straw-coloured, up to 320 µm long x 5.5-8.5 µm thick at base tapering to 3-4.5 µm near the apex, slightly enlarged at the apex to 4-5 µm thick and bearing a whorl of 7-9 phialides. Conidiogenous cells monophialidic, discrete, terminal, clavate, 10-14 x 4-5.25 µm, hyaline, pale straw-coloured or pale brown. Conidia aggregated in slimy, black, glistening heads, acrogenous, cylindrical, apex rounded, base rounded or truncate, black or dark brown, coarsely verrucose, non-septate, (10-) 11-13 (-15) x (3.5-) 4-4.5 (-5.25) µm.

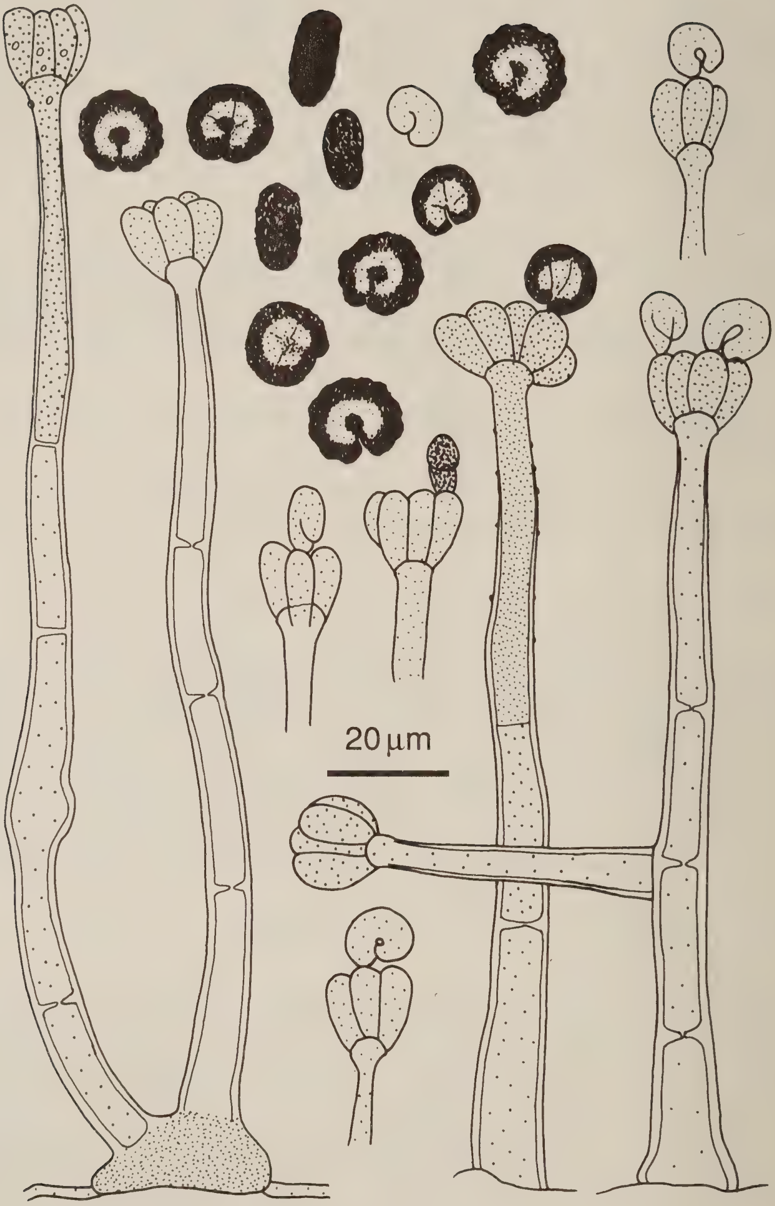

Figure 3. *Stachybotrys nephrodes*, conidiophores and conidia from host (PDD 57627, type). Specimen mounted in hydrous lactophenol.

On *Freycinetia baueriana* ssp. *banksii*
Specimens examined: **New Zealand**, NORTHLAND, Puketi, 24.I.1985, R.E. Beever (PDD 57654); Ngaiotonga Scenic Reserve, May 1985, G.J. Samuels (PDD 57655); Waipoua Forest, Yakas Kauri Track, 20.X.1987, E.H.C. McKenzie & P.R. Johnston (PDD 57660); Waipoua Forest, Te Matua Ngahere Track, 20.X.1987, E.H.C. McKenzie & P.R. Johnston (PDD 57664); Waima, Waiotemarama Track, 21.X.1987, E.H.C. McKenzie & P.R. Johnston (PDD 57659); Omahuta State Forest, Kauri Reserve, 22.X.1987, E.H.C. McKenzie & P.R. Johnston (PDD 57649); Omahuta State Forest, Kauri Reserve, 22.X.1987, E.H.C. McKenzie & P.R. Johnston (PDD 57650); Puketi, 23.X.1987, E.H.C. McKenzie & P.R. Johnston (PDD 57643). AUCKLAND, Swanson, Tram Valley Road, 30.III.1983, E.H.C. McKenzie (PDD 57646); Waitakere Range, Fairy Falls Track, 3.II.1984, P.R. Johnston (PDD 57645); Hunua Range, Waharua Regional Park, 18.V.1985, R.E. Beever (PDD - 57653); Waitakere Range, Spraggs Bush, 21.IV.1987, R.E. Beever (PDD 57666). COROMANDEL, Kauaeranga Valley, Moss Creek Hut Track, 30. VIII.1986, E.H.C. McKenzie (PDD 57662); Little Barrier Island, Tirikakawa Stream, 15.VI.1984, P.R. Johnston (PDD 57641); Little Barrier Island, Awaroa Stream, June 1984, P.R. Johnston (PDD 57640); Waiomu, Crosbies Hut Track, 31.VIII.1986, E.H.C. McKenzie (PDD 57642); Kauaeranga Valley, Tarawaere Dam Track, 1.IX.1986, E.H.C. McKenzie (PDD 57657); Little Barrier Island, Summit Track, 7.IV.1988, E.H.C. McKenzie (PDD 57663). WAIKATO, Mt Pirongia, Track 1, 27.III.1984, E.H.C. McKenzie (PDD 57651); Mt Pirongia, Track 3, 19.XI.1984, E.H.C. McKenzie (PDD 57639 - **holotype**); Mt Pirongia, 21.V.1988, E.H.C. McKenzie (PDD 57647). BAY OF PLENTY, Kaimai-Mamaku Forest Park, Tuahu Track, 11.VI.1985, G.J. Samuels & P.K. Buchanan (PDD 57658). TARANAKI, Rotokare Walk, 13.XII.1989, E.H.C. McKenzie & P.R. Johnston (PDD 57644); Rotorangi Hydro Walk, 14.XII.1989, E.H.C. McKenzie & P.R. Johnston (PDD 57661). MARLBOROUGH SOUNDS, Durville Island, Mt Maude, 17.I.1988, R.E. Beever (PDD 57648); Durville Island, track to Bullock Bay, 23.I.1988, R.E. Beever (PDD 57665). WESTLAND, near Haast, 23.II.1987, V. & R.C. Cooper (PDD 57656); Gillespies Beach Forest, 24.II.1987, V. & R.C. Cooper (PDD 57652).

The specific epithet refers to the host genus on which this species is commonly found.

Stachybotrys nephrodes McKenzie sp. nov. Fig. 3

Mycelium partim internum et externum. Conidiophora macronematosa, mononematosa, solitaria vel fasciculata, interdum ramosa, erecta, recta vel paulo flexuosa, laevia vel interdum verrucosa, septata, grisea vel pallide brunnea, saepe apicem versus obscura, usque ad 200 μm longa, basi 6-12 μm, prope apicem 4-5 μm, apice inflata 5-6.5 μm diam. Cellulae conidiogenae monophialidicae, discretae, 5-9 in verticillo dispositae, clavatae, 11-13 x 6-6.5 μm, grisea vel pallide brunnea. Conidia in massis globosis aggregata, acrogena, stricte torta vel stricte reniformia, eseptata; visu frontali subglobosa, pallide olivacea cum zona extrema nigra vel atro-brunnea, 1.75-4.5 μm crassa, verrucosa, (11-) 13-15 (-15.5) x (10.5-) 12-14 μm; visu laterali cylindrica, nigra vel atro-brunnea 11.5-15 (-16) x 5.5-7.5 μm.

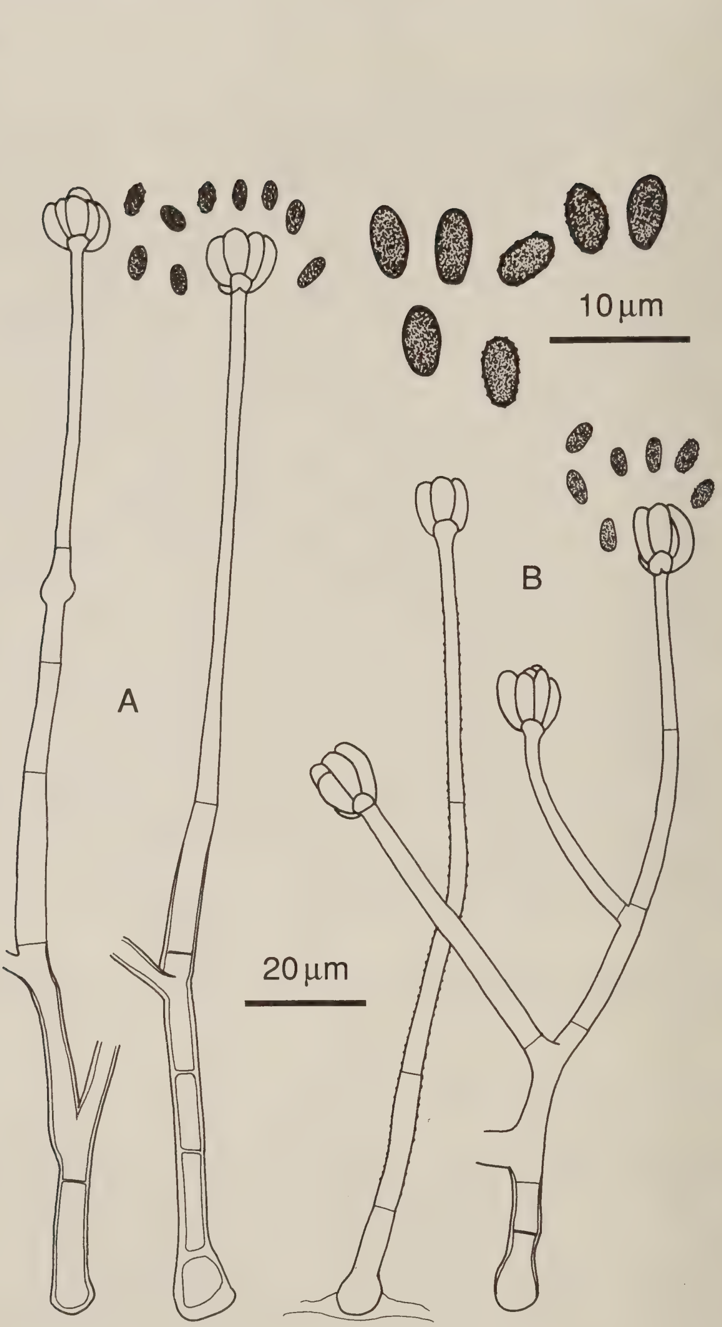

Figure 4. *Stachybotrys parvispora*, conidiophores and conidia from host (A, PDD 57585; B, PDD 53670). Specimens mounted in hydrous lactophenol.

In foliis mortuis pandanacearum *Freycinetia* sp. et *Pandanus* sp.
Holotypus PDD 57627.

Mycelium partly superficial, partly immersed. Conidiophores macronematous, mononematous, single or in groups, sometimes branched, erect, straight or slightly flexuous, smooth or occasionally verrucose, septate, hyaline, greyish or pale brown, often darkest towards the apex, up to 200 μm long x 6-12 μm thick at base tapering to 4-5 μm near the apex, slightly enlarged at the apex to 5-6.5 μm thick and bearing a whorl of 5-9 phialides. Conidiogenous cells monophialidic, discrete, terminal, clavate, 11-13 x 6-6.5 μm, greyish or pale brown. Conidia aggregated in slimy, black, glistening heads, acrogenous, tightly curled or tightly reniform, non-septate; in face view subglobose, pale olivaceous with a 1.75-4.5 μm black or dark brown outer zone, verrucose, (11-) 13-15 (-15.5) x (10.5-) 12-14 μm; in side view cylindrical, black or dark brown 11.5-15 (-16) x 5.5-7.5 μm.

On *Freycinetia* spp.
Specimens examined: **American Samoa**, TUTUILA, June 1987, P.C. Gardner (PDD 57631); 4.V.1989, E.H.C. McKenzie (PDD 57627 - **holotype**). **Solomon Islands**, UPEI ISLAND, Marovo Lagoon, 28.VI.1986, A. Worsnop (PDD 57632). **Western Samoa**, UPOLU, Afiamalu, 12.XII.1985, E.H.C. McKenzie (PDD 57630); Mafa Pass, 8.III.1987, E.H.C. McKenzie (PDD 57629).

On *Pandanus* sp.
Specimen examined: **Western Samoa**, UPOLU, June 1987, P.C. Gardner (PDD 57628).

The specific epithet refers to the kidney shape of the conidia.

Stachybotrys parvispora Hughes, *Mycological Papers 48*: 74, 1952. Fig. 4

Mycelium partly superficial, partly immersed, hyaline, 1-1.5 μm thick. Conidiophores macronematous, mononematous, single or in groups, branched, erect, straight or slightly flexuous, smooth or verrucose, septate, hyaline, up to 160 μm long x 6-7 μm thick at base tapering to 2.25-3 μm near the apex, slightly enlarged at the apex to 3-4 μm thick and bearing a whorl of 5-9 phialides. Conidiogenous cells monophialidic, discrete, terminal, ellipsoidal, 8.5-11 x 3.5-4.5 μm, hyaline. Conidia aggregated in slimy, black, glistening heads, acrogenous, oval, apex rounded, base rounded or truncate, olivaceous-brown, smooth or verrucose, non-septate, 5-6.5 (-7) x 2-3 (-3.5) μm.

On *Freycinetia wilderi*
Specimens examined: **Cook Islands**, RAROTONGA, 5.XI.1984, P.J. Brook (PDD 53668, 53669); August 1987, R.A. Fullerton (PDD 53892); south of Te Rua Manga 9.IX.1987, R.E. Beever (PDD 53894); Cross Island Track, 24.VI.1990, G. McCormack (PDD 57586, 57669).

On *Freycinetia* spp.
New Caledonia, Mt des Koghis, 15.XI.1987, E.H.C. McKenzie (PDD 57585).
Solomon Islands, GUADALCANAL, Mt Austen, 23.III.1986, E.H.C. McKenzie (PDD 53667, 53670).

The collections of this fungus match the description of the type (Hughes 1952) and that of Jong & Davis (1976). It is known in tropical areas on dead plant material, especially leaves, and from soil.

Acknowledgement

I gratefully acknowledge the assistance of Dr G. Kuschel in the preparation of the Latin diagnoses. I thank Dr Gareth Morgan-Jones, Department of Plant Pathology, College of Agriculture and Alabama Agricultural Experiment Station, Auburn University, Auburn, Alabama, USA for critical review of this paper.

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MYCOTAXON

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DEMATIACEOUS HYPHOMYCETES ON FREYCINETIA (PANDANACEAE). 2. ZEBROSPORA GEN. NOV.

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Abstract

A new monotypic hyphomycete genus, *Zebrospora*, is described. It is commonly found on dead leaves of *Freycinetia* spp. and is known from Cook Islands, New Caledonia, New Zealand, and Western Samoa. Conidiogenous cells are polyblastic with prominent scars. The conidia are 3-septate, dark reddish-brown, with a dark band at each septum and a hyaline band on the outer edge of the two end septa. The genus is compared with the similar genus, *Duosporium*.

Introduction

During an examination of 62 samples of dead *Freycinetia* leaves from eight countries, approximately 80 species of dematiaceous hyphomycetes were found. Four species of *Stachybotrys* have been described (McKenzie 1991), and all the other species will be described in this and subsequent papers. All fungal specimens are deposited in the herbarium of DSIR Plant Protection (PDD).

Zebrospora bicolor gen. et sp. nov. Figs. 1-3
Deuteromycotina, Hyphomycetales

Mycelium internum, ex hyphis pallide luteis, 2-3 μm crassis compositum. Conidiophora macronematosa, mononematosa, solitaria vel caespitosa, eramosa, erecta, recta vel flexuosa, laevia, septata, obscure rubro-brunneae, apicem versus pallidiora, usque ad 500 (-750) μm longa x 7-11 μm crassa, ad apicem inflata 10-16 μm diam. Cellulae conidiogenae polyblasticae, in conidiophoris incorporatae, terminales, interdum intercalares, sympodiales, cylindricae vel clavatae; cicatrices conidiales 4-8 μm latae, rubro-brunneae. Conidia solitaria, acropleurogena, recta, cylindrica, laevia, extremis verrucosa, obscure rubro-brunnea, utrisque extremis obscuriora, cellula apicali et basali rotundata, (29-) 32-36 (-40.5) x 10.5-12.5 μm, 3-septata, interdum septo medio leviter constricto, ad quodque septum saepe anulo atro, anulis in quibusque extremis margine externa hyalina.

In foliis mortuis pandanacearum *Freycinetia baueriana* Endl. ssp. *banksii* (Cunn.) Stone, *F. wilderi* Mart., et *Freycinetia* spp.
Holotypus PDD 57681.

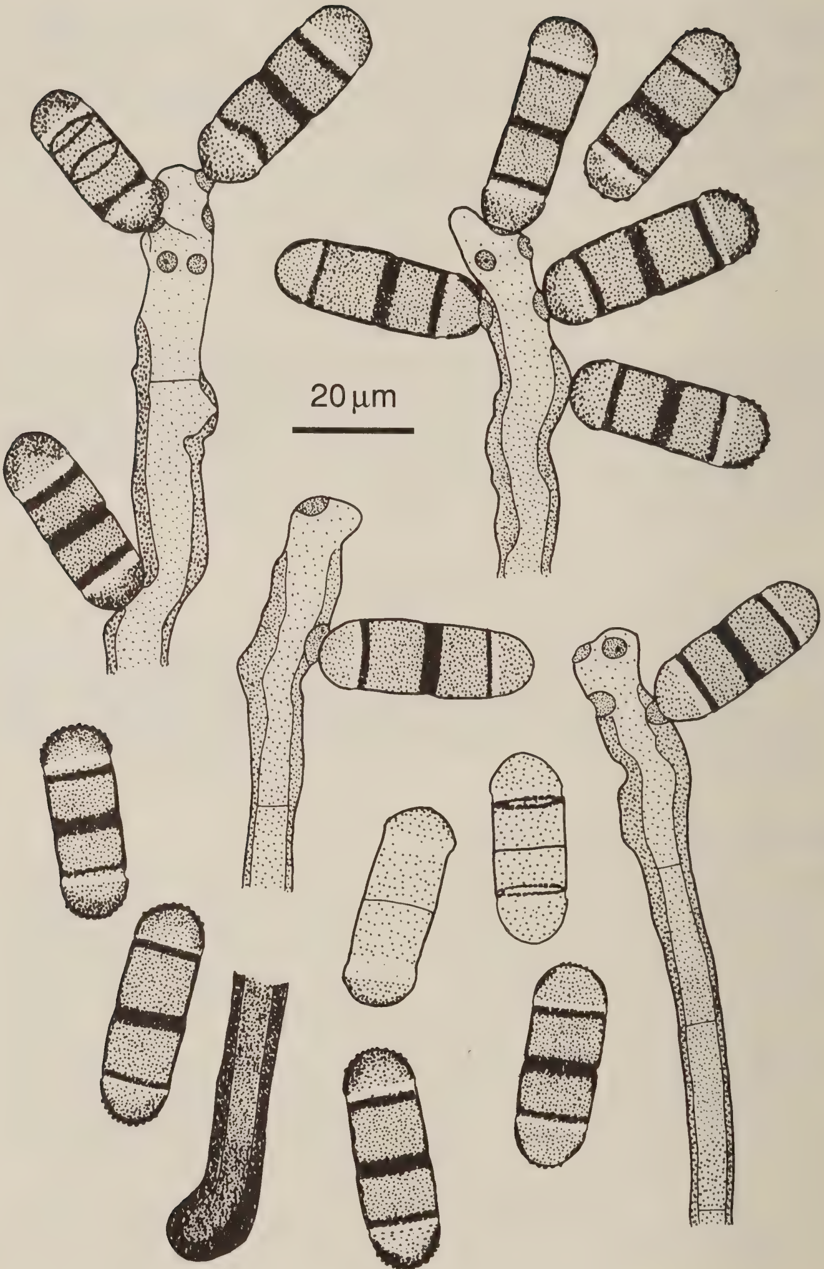

Figure 1. *Zebrospora bicolor*, conidiophores and conidia from host (PDD 57681, type). Specimen mounted in hydrous lactophenol.

Colonies often associated with a yellowish discolouration of the leaf tissue. Hyphae immersed, pale yellowish, 2-3 μm thick. Conidiophores macronematous, mononematous, single or caespitose, unbranched, erect, straight or flexuous, smooth, septate, dark reddish-brown, paler near the apex, up to 500 (-750) μm long x 7-11 μm thick, swollen at apex to 10-16 μm. Conidiogenous cells polyblastic, integrated, terminal sometimes becoming intercalary, sympodial, cylindrical or clavate, conidial scars 4-8 μm diam., reddish-brown and prominent. Conidia solitary, acropleurogenous, straight, cylindrical, verrucose on the rounded ends, (29-) 32-36 (-40.5) x 10.5-12.5 μm, 3-septate, sometimes slightly constricted at the middle septum, dark reddish-brown, darker towards each end, frequently with a dark band at each septum, hyaline band present on the outer edge of the two end septa. The hyaline band is a point of weakness and if any pressure is applied conidia will often break at this point (Fig. 2). When viewed by scanning electron microscopy, conidia are seen to be verrucose over all the surface, and enveloped by a thin mucilagenous sheath (Fig. 3). On one occasion the fungus was cultured on malt extract agar; it produced a slow-growing, pale brown colony with abundant sporulation at the periphery.

The generic name refers to the circular hyaline and dark bands on the conidia.

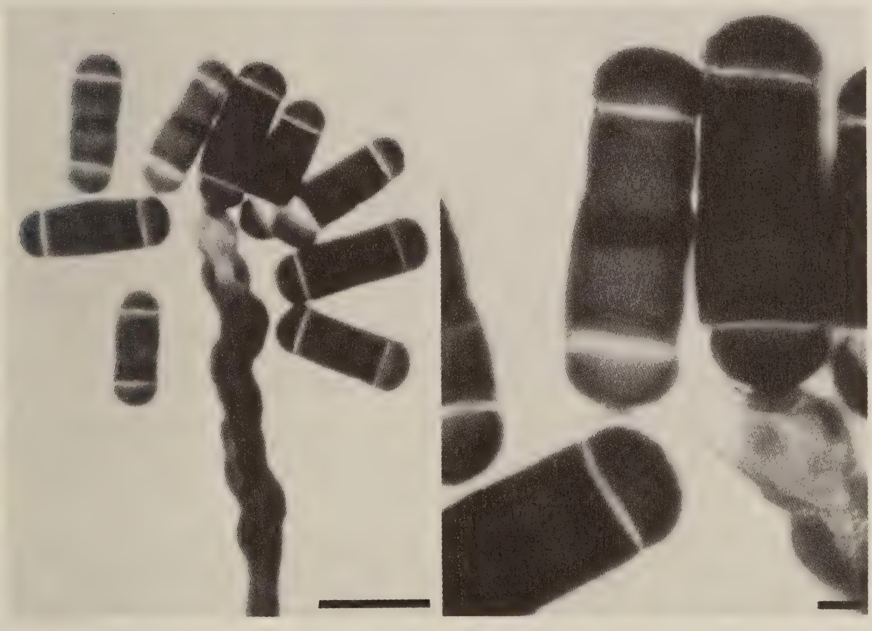

Figure 2. *Zebrospora bicolor*, conidiophores and conidia from host (PDD 57681, type). Bar = 10 μm.

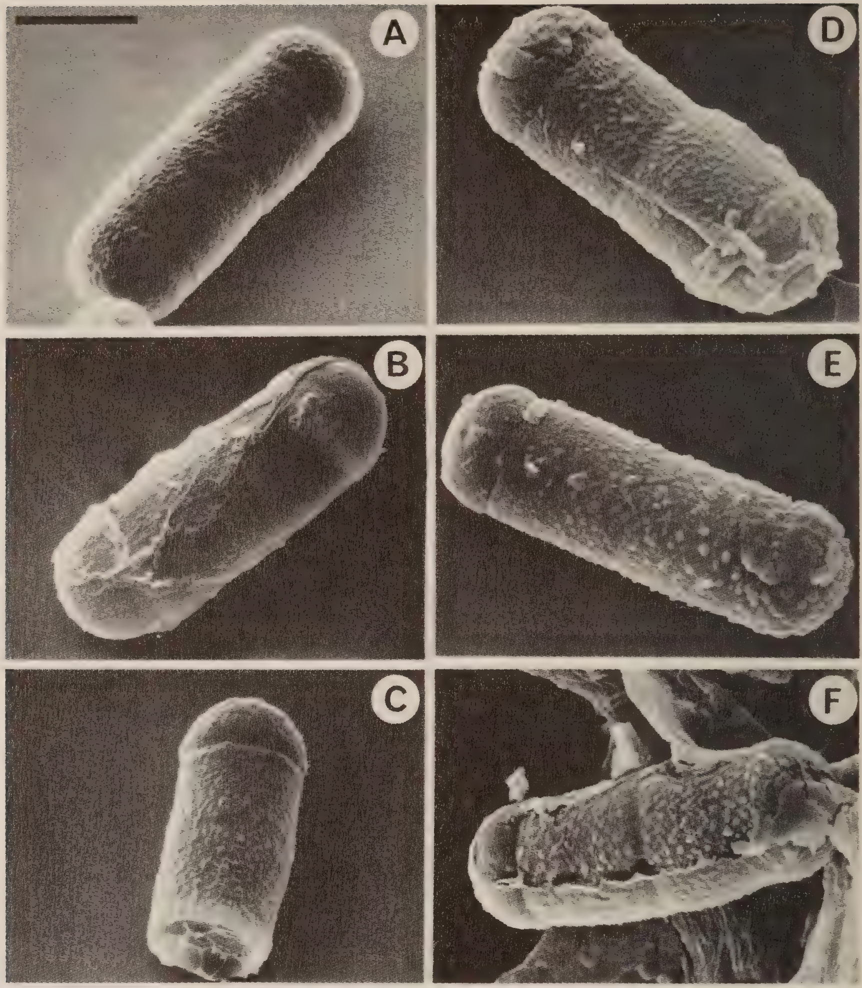

Figure 3. *Zebrospora bicolor*, conidia from host, A-C (PDD 57682); D,E (PDD 57688); F (PDD 57683). Bar = 10 μm.

On *Freycinetia baueriana* Endl. ssp. *banksii* (Cunn.) Stone
Specimens examined: **New Zealand**, NORTHLAND, Puketi, 21.IV.1985, R.E. Beever (PDD 57685); Ngaiotonga Scenic Reserve, May 1985, G.J. Samuels (PDD 57687); Waipoua Forest, Te Matua Ngahere Track, 20.X. 1987, E.H.C. McKenzie (PDD 57689); Waima, Waiotemarama Track, 21.X. 1987, E.H.C. McKenzie (PDD 57688); Omahuta State Forest, Kauri Reserve, 22.X.1987, E.H.C. McKenzie (PDD 57679; PDD 57681 - **holotype**);

Puketi, 23.X.1987, E.H.C. McKenzie (PDD 57682). AUCKLAND, Swanson, Tram Valley Road, 30.III.1983, E.H.C. McKenzie (PDD 57673); Waitakere Range, Fairy Falls Track, 3.II.1984, P.R. Johnston (PDD 57690); Hunua Range, Waharua Regional Park, 18.V.1985, R.E. Beever (PDD 57680). COROMANDEL, Little Barrier Island, Awaroa Stream, June 1984, P.R. Johnston (PDD 57675); Kauaeranga Valley, Moss Creek Hut Track, 30.VIII.1986, E.H.C. McKenzie (PDD 57678); Kauaeranga Valley, Tarawaere Dam Track, 1.IX.1986, E.H.C. McKenzie (PDD 57677); Little Barrier Island, Summit Track, 7.IV.1988, E.H.C. McKenzie (PDD 57686). WAIKATO, near Kawhia, Te Kauri Reserve, 20.V.1988, E.H.C. McKenzie (PDD 57672). TARANAKI, Rotokare Walk, 13.XII.1989, E.H.C. McKenzie (PDD 57684); Rotorangi Hydro Walk, 14.XII.1989, E.H.C. McKenzie (PDD 57683). MARLBOROUGH SOUNDS, Durville Island, track to Bullock Bay, 23.I.1988, R.E. Beever (PDD 57676). NELSON, Puponga Farm Park, 13.II.1987, V. & R.C. Cooper (PDD 57674).

On *Freycinetia wilderi* Mart.
Specimens examined: **Cook Islands**, RAROTONGA, 5.XI.1984, P.J. Brook (PDD 57692); track to south of Te Rua, 9.IX.1987, R.E. Beever (PDD 57693); Cross Island Track, 24.XI.1990, G. McCormack (PDD 57694).

On *Freycinetia* spp.
Specimens examined: **Western Samoa**, UPOLU, Afiamalu, 15.XI.1986, W.W.P. Gerlach (PDD 57691). **New Caledonia**, Mt Panié, 1300 m, 15.XII. 1990, J.S. Dugdale (PDD 58238).

Zebrospora has similar morphology to genera such as *Acroconidiella, Curvularia,* and *Duosporium.* Superficially, the conidia most closely resemble those of the monotypic genus *Duosporium.* However, *Zebrospora bicolor* differs in lacking the secondary conidia characteristic of *Duosporium yamadanum* (Matsuura) Tsuda & Ueyama (1982), in growing and sporulating on malt extract agar, and in the distinctive colour pattern of the conidia. *D. yamadanum* is pathogenic to *Cyperus* spp.; *C. bicolor* is known only on dead leaves of *Freycinetia.* It is one of the more common dematiaceous hyphomycete species found on *Freycinetia* leaves.

Acknowledgements

I gratefully acknowledge the assistance of Dr G. Kuschel in the preparation of the Latin diagnosis. Ms K.J. Head, DSIR Plant Protection, Auckland kindly carried out the SEM work. I thank Dr J.L. Alcorn, Department of Primary Industries, Indooroopilly, Queensland, Australia for critical review of this paper.

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Tsuda, M.; Ueyama, A. 1982: *Duosporium yamadanum*, a pathogen of *Cyperus* spp. *Mycotaxon 14*: 145-148.

MYCOTAXON

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FUNGI OF THE CHATHAM ISLANDS

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Abstract

A short historical account is given of fungal collections from the Chatham Islands, New Zealand, followed by an annotated list of the fungi, and an alphabetical host list. Most of the records are based on collections made by the author in March 1983, when particular attention was given to fungi causing plant diseases, although conspicuous macrofungi and some leaf litter samples were also collected. The list contains 123 named species of fungi including eight unpublished, new taxa. One pathogen, *Puccinia crepidicola* H. & P. Sydow is recorded in New Zealand for the first time, and 30 new host/pathogen records are given for 26 other species.

Keywords Chatham Islands; New Zealand; fungi; new records; host plants

The Chatham Islands (44° S, 176° W) lie approximately 860 km east of Christchurch, New Zealand (Fig. 1). The group, with a total land area of less than 100,000 ha, is composed of two main islands (Rekohu or Chatham and Rangiauria or Pitt) and several smaller islands, rocks and stacks. Although both Chatham and Pitt were originally covered with forest, wetland and rushland, most of the vegetation today is severely modified and large areas are grazed by sheep and cattle.

Accounts of the vegetation are provided by Devine (1982), Kelly (1983) and Given & Williams (1985). The over-riding impressions of today's plant cover are of the extensive moorland-like vegetation dominated by bracken (*Pteridium esculentum* (Forst. f.) Cockayne) and umbrella fern (*Gleichenia* sp.), the omnipresent exotic pasture plants, a peatland community of *Sporodanthus traversii* (F. Muell.) Kirk and shrubs on the southern tablelands, and the extensive *Dracophyllum arboreum* Ckn. dominated forest in the south. The vascular plant flora consists of about 320 native species, including 37 endemic plant taxa, and about 200 adventive species (Madden & Healy 1959, Given & Williams 1985), along with a range of cultivated plants.

Few fungi are known from the Chatham Islands, and there has been no previous systematic attempt to collect and study them. The naturalist H. H. Travers visited in 1863 and 1871. His 1863 plant collections, which apparently did not include any fungi, were sent to Melbourne and described

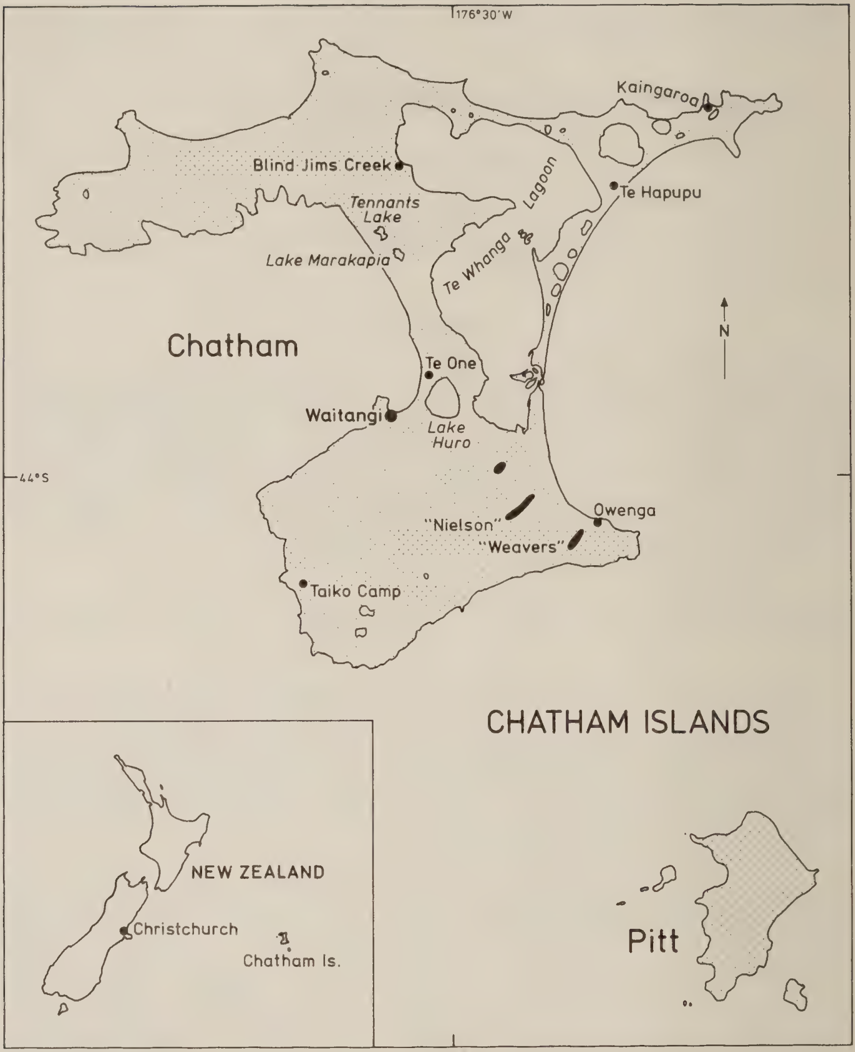
176°30'W
44°S
Kaingaroa
Blind Jims Creek
Tennants Lake
Lake Marakapia
Te Whanga Lagoon
Te Hapupu
N
Chatham
Te One
Waitangi
Lake Huro
"Nielson"
"Weavers"
Owenga
Taiko Camp
CHATHAM ISLANDS
NEW ZEALAND
Christchurch
Chatham Is.
Pitt

Figure 1. Location of Chatham Islands, and main collecting sites.

by Mueller (1864). Travers collected fungi during his second visit (Mueller 1872) but the fate of most of his fungal collections is largely unknown. A list of his fungi was never published and only a few collections have been cited in the literature. Six of Travers' fungal specimens are held in the National Herbarium of Victoria (MEL), and two of these are duplicated in

Kew herbarium. Cunningham (1952) cites two other Travers specimens from Chatham Islands, held at Kew. Saccardo (1887, 1888) listed three fungi from the Chatham Islands. These three records were carried forward by Cooke (1892a). With respect to one of these, *Grandinia ocellata* Fr., the copy of Cooke's book held at DSIR Plant Protection, has been annotated by G. H. Cunningham 'not at Kew'. The rust, *Melampsora hypericorum* Wint. was collected on *Hypericum androsaemum* L. by E. A. Madden in 1954, and included in the list of specimens seen by Baker (1956). Cunningham (1931) listed Chatham Islands as a locality for the rust, *Uromyces microtidis* Cooke on *Microtis unifolia* (Forst. f.) Reichb., but there were no further details and no specimen is held in the herbarium of DSIR Plant Protection (PDD). In 1924 E. F. Northcroft was a member of an Otago Institute expedition to the Chatham Islands. Northcroft sent fungal specimens to C. G. Lloyd, in Cincinnati, Ohio, U.S.A., and eight of these were listed from the Chatham Islands (Lloyd 1924). To date only one fungal species, *Chromosporium pallescens* Cooke & Massee has been described from the Chatham Islands (Cooke 1892b). However, as a result of the author's visit to Chatham Islands, a new species has been described (Samuels et al. 1987) and descriptions of seven other new taxa are in preparation. In herb. PDD there were, prior to 1983, six specimens of fungi from Chatham Islands. Of these six fungi, *Auricularia polytricha* (Mont.) Sacc. and *Physalacria stilboidea* (Cooke) Sacc. were re-collected by the author in 1983.

The author visited Chatham Islands from 4 to 14 March 1983. While particular attention was given to diseased plants, conspicuous macrofungi and leaf litter samples were also collected. The main collecting sites, all on Chatham Island, are shown in Fig. 1. Apart from a few specimens collected in a private garden near Waitangi, all others were taken from naturalised or indigenous vegetation. Specimens were dried and taken to Auckland for examination. Most collections are housed in the herbarium of DSIR Plant Protection (PDD), but a few have been lodged in the Institut für Spezielle Botanik, Zurich (ZT).

The following list contains 123 named species of fungi. One pathogen, *Puccinia crepidicola* H. & P. Syd. is recorded in New Zealand for the first time, and a further 30 new host/pathogen records for New Zealand are indicated by an asterisk (*). All specimens have been collected by the author on Chatham Island in March 1983, unless otherwise stated. The group to which each fungus belongs is denoted by a letter after the author citation thus: A = Ascomycotina, B = Basidiomycotina, D = Deuteromycotina. For the rust fungi, I indicates the presence of aecia, II uredinia, and III telia.

THE FUNGI

Agaricus sp. (B)
in pasture (PDD 44586).

Aleurodiscus mirabilis (Berkeley & Curtis) Höhnel, *Sber. Akad. Wiss. Wien 118*: 818, 1909 (B)
on twigs (PDD 44730).
Small discoid, cream coloured fruitbodies up to 3 mm diam. Common in the North Island of New Zealand on bark of dead branches.

Alternaria sp. (D)
on *Lolium perenne* L. (PDD 52037).

Ascochyta sp. (D)
on *Vicia sativa* L. (PDD 44052).
Associated with blighted leaves.

Auricularia polytricha (Montagne) Saccardo, *Atti Ist. veneto Sci., Ser. 6, 3*: 722, 1885 (B)
on *Plagianthus* sp. PDD 39242 - Rangatira (South East Island), 1 Jan 1970, leg. B. G. Hamlin (2040).
on fallen log (PDD 43837, 43838); MEL - labelled *Hirneola hispidula* Berk., H. H. Travers (No. 155); (Saccardo 1888 - as *Hirneola polytricha* - locality cited as 'Chat s isl.'); (Cooke 1892a - as *Hirneola polytricha*); (Massee 1906 - as *Hirneola polytricha*); (Lloyd 1924 - sent by E. F. Northcroft); (McNabb 1964 - Chatham Islands, F61).
Wood ear fungus. Widespread and common throughout New Zealand on dead wood of many different tree species.

Bjerkandera adusta (Willdenow) P. Karsten, *Meddn Soc. Fauna Flora fenn. 5*: 38, 1879 (B)
on fallen log (PDD 44738); (Lloyd 1924 - as *Polyporus adustus* - sent by E. F. Northcroft).
Polypore bracket fungus. Fruitbodies annual, on fallen branches and trunks. Widespread in New Zealand.

Blumeria graminis (de Candolle ex Mérat) Speer, *Sydowia 27*: 2, 1975 (A)
*on *Bromus mollis* L. (PDD 43910).
Powdery mildew. Widespread on introduced grasses and cereals in New Zealand.

Buergenerula zelandica McKenzie, ined. (A)
*on *Carex virgata* Boott (PDD 44179, 44180, 44183, 44224).
Leaf spot. Elongate, dark brown lesions, coalescing and covering large parts of the leaf. This species has since been found on *Carex sinclarii* Boott in the North Island (McKenzie 1987).

Calvatia utriformis (Bulliard) Jaap, *Verh. bot. Ver. Prov. Brandenb. 59*: 37, 1917 (B)
MEL - labelled *Lycoperdon coelatum* (*exoletum*), H. H. Travers (No. 1).
Puffball. Up to 10 cm diam., on ground in grass. Widespread in New Zealand.

Cercospora microlaenae McKenzie & Latch, *N. Z. Jl agric. Res. 27*: 115, 1984 (D)
on *Microlaena stipoides* R. Br. (PDD 44073).
Leaf spot. Common on this grass in the Auckland area.

Cercospora zebrina Passerini, *Hedwigia 16*: 124, 1877 (D)
on *Medicago arabica* (L.) Hud. (PDD 44062).
Leaf spot. Common on spotted medick and clovers throughout New Zealand.

Chalara australis McKenzie, ined. (D)
on *Dracophyllum arboreum* Ckn. (PDD 52058).
Saprophytic on fallen leaves.

Chalara distans McKenzie, ined. (D)
on *Dracophyllum arboreum* Ckn. (PDD 49389).
Saprophytic on fallen leaves.

Cheilymenia raripila (Phillips) Dennis, *Kew Bull. 14*: 428, 1960 (A)
on cow dung (PDD 46778).
Small, ca. 0.5-1 mm diam., pale orange coloured apothecia. Apparently restricted to cow dung (Rifai 1968).

Chromosporium pallescens Cooke & Massee in Cooke, *Grevillea 21*: 1, 1892 (D)
among mosses (Cooke 1892b - leg. Kirk 383).
This fungus was described from a Chatham Islands collection. According to Hughes (1958) *Chromosporium* is a nomen dubium.

Circinotrichum chathamiensis McKenzie, ined. (D)
on *Myrsine chathamica* F. Muell. (PDD 49391).
Saprophytic on fallen leaves.

Circinotrichum maculiforme Nees, *Syst. Pilze Schw.*: 18, 1816 (D)
on *Ripogonum scandens* J. R. & G. Forst. (PDD 49392).
Saprophytic on fallen leaves.

Circinotrichum papakurae Hughes & Pirozynski, *N. Z. Jl Bot. 9*: 40, 1971 (D)
on *Corynocarpus laevigatus* J. R. & G. Forst. (PDD 49393).
Saprophytic on fallen leaves. Described from New Zealand on fallen leaves of *Beilschmiedia tarairi* (A. Cunn.) Benth. & Hook. f.

Claviceps purpurea (Fries) Tulasne, *Annls Sci. nat. Bot. Sér. 3, 20*: 45, 1853 (A)
on *Ammophila arenaria* (L.) Link (PDD 43849, 43852).
on *Critesion murinum* (L.) Löve (PDD 44173, 44176).
on *Dichelachne crinita* (Linné f.) Hook. f. (PDD 44065).
on *Echinopogon ovatus* (Forst. f.) Beauv. (PDD 52042).
on *Holcus lanatus* L. (PDD 44055).
on *Lolium perenne* L. (PDD 43893).
*on *Rytidosperma unarede* (Raoul) Connor & Edgar (PDD 43846, 44050).
Ergot. Common and widespread on seedheads of many grass and cereal hosts in New Zealand.

Codinaea simplex Hughes & Kendrick, *N. Z. Jl Bot. 6*: 362, 1968 (D)
on *Cyathodes robusta* Hook. f. (PDD 49394).
on *Dracophyllum arboreum* Ckn. (PDD 49395).
Saprophytic on fallen leaves. Described from New Zealand on bark.

Colletotrichum graminicola (Cesati) Wilson, *Phytopathology 4*: 110, 1914 (D)
on *Hierochloe redolens* (Vahl) Roem. & Schult. (PDD 43934).
on *Holcus lanatus* L. (PDD 43898).
on *Lolium perenne* L. (PDD 46733).
*on *Rytidosperma clavatum* (Zotov) Connor & Edgar (PDD 43923).
Associated with a leaf spot on *H. lanatus*, and with senescing leaves and stems on the other three grasses. Symptoms of infection by *C. graminicola* are often obscure, but in New Zealand distinct lesions have been described for *H. redolens* (McKenzie & Latch 1984) and for *L. perenne* (Latch 1966).

Cryptophiale insularis McKenzie, ined. (D)
on *Dracophyllum arboreum* Ckn. (PDD 49399).
Saprophytic on fallen leaves.

Cystolepiota sp. (B)
on wood (ZT 1879).

Dactylaria sp. (D)
on *Carex lessoniana* Steud. (PDD 52059).
on *Carex virgata* Boott (PDD 52060).

Daldinia concentrica (Bolton) Cesati & de Notaris, *Comment. Soc. Critt. Ital. 1*: 197, 1863 (A)
on dead stump of *Olearia traversii* (F. Muell.) Hook. f. PDD 39243 - Te One Stream near Owenga, 9 Jan 1970, leg. B.G. Hamlin (2041).
Cramp balls. Conspicuous reddish-brown to black fruit bodies up to 6 cm diam. Widespread throughout New Zealand. Usually saprophytic but may occur as a wound pathogen on a wide range of host plants.

Diplocarpon rosae Wolf, *Bot. Gaz. 54*: 231, 1912 (A)
anamorph *Marssonina rosae* (Libert) Diedicke, *Krypt. Fl. Mk Brandenb. 9*: 830, 1915
on *Rosa* sp. cult. (PDD 44107).
Black spot of roses. A common disease in New Zealand.

Drechslera dematioidea (Bubák & Wroblewski) Subramanian & Jain, *Curr. Sci. 35*: 354, 1966 (D)
on *Hierochloe redolens* (Vahl) Roem. & Schult. (PDD 43933).
On dead stem. Previously recorded in New Zealand on seed of several grass species (McKenzie 1978), and causing shoot blight of *Leucospermum nutans* R. Br. (Boesewinkel 1986).

Drechslera phlei (Graham) Shoemaker, *Can. J. Bot. 37*: 881, 1959 (D)
on *Rytidosperma unarede* (Raoul) Connor & Edgar (PDD 44072).
Found only on senescing leaves. Previously recorded in New Zealand on seed of *Lolium perenne* and *Phleum pratense* L. (McKenzie 1978).

Drechslera cf. ***triseptata*** (Drechsler) Subramanian & Jain, *Curr. Sci. 35*: 355, 1966 (D)
on *Holcus lanatus* L. (PDD 52043).
Found only on senescing and dead leaves. *D. triseptata* has been previously recorded in New Zealand on seed of several grass species (McKenzie 1978).

Dreschlera sp. (D)
on *Rytidosperma unarede* (Raoul) Connor & Edgar (PDD 43993).

Elsinoe veneta (Burkholder) Jenkins, *J. agric. Res. 44*: 696, 1932 (A)
anamorph *Sphaceloma necator* (Ellis & Everhart) Jenkins & Shear, *Phytopathology 36*: 1047, 1946
on *Rubus fruticosus* L. (PDD 44121).
Cane spot or anthracnose. Small light coloured spot with a dark reddish margin on leaves or canes. Widespread in New Zealand on introduced *Rubus* spp.

Entyloma calendulae (Oudemans) de Bary, *Bot. Ztg 32*: 102, 1874 (B)
on *Calendula officinalis* L. (PDD 46729).
Calendula smut. Sori in leaves, as round greenish to brown spots. Found on cultivated calendula throughout New Zealand.

Entyloma dactylidis (Passerini) Ciferri, *Boll. Soc. bot. ital. 1924(2)*: 55, 1924 (B)
on *Agrostis stolonifera* L. (PDD 44139).
on *Dactylis glomerata* L. (PDD 44220).
Leaf smut. Sori in leaves as black or leaden-grey oval to linear spots. Widespread throughout New Zealand.

Entyloma heteromeria McKenzie, ined. (B)
*on *Hydrocotyle heteromeria* A. Rich. (PDD 52061, 52062).
Leaf smut. Sori in leaves as grey or black subcircular spots.

Erysiphe trifolii Greville, *Fl. edin.*: 459, 1824 (A)
on *Trifolium dubium* Sibth. (PDD 44061).
Powdery mildew of clovers. In New Zealand it infects several species of *Trifolium* and some other legumes.

Eudarluca caricis (Fries) O. Eriksson, *Bot. Notiser 119*: 35, 1966 (A)
anamorph *Sphaerellopsis filum* (de Bivona-Bernardi) Sutton, *Mycol. Pap. 141*: 196, 1977
on *Puccinia cockaynei* on *Gentiana chathamica* Cheesem. (PDD 44083).
on *Uredo scirpi-nodosi* on *Isolepis inundata* R. Br. (PDD 50834).
Hyperparasitic in sori of rust fungi. Common and widespread in New Zealand on many different species of rust.

Fomes pomaceus (Persoon) Lloyd (Lloyd 1924) = *Phellinus pomaceus* (Persoon) Maire

Ganoderma applanatum (Persoon) Patouillard, *Bull. Soc. mycol. Fr. 5*: 67, 1889 (B)
on fallen log (PDD 44741).
Polypore bracket fungus. Associated with a white heart rot of living trees. Large fruitbodies, up to 16 cm diam. and 6 cm thick, occur on dead standing and fallen trunks. Widespread and common in New Zealand on many woody hosts.

Geastrum triplex Junghuhn, *Tijdschr. Natuurl. Gesch. Physiol. 7*: 287, 1840 (B)
MEL - originally named *Geaster saccatus* Fr., leg. H. H. Travers. Redetermined as *Geastrum triplex* by J. Willis, 4 Aug 1956; K - D. A. Reid, pers. comm. - filed as *Geastrum saccatum*.
Earthstar. Widespread in New Zealand, usually on litter on ground.

Glomerella cingulata (Stoneman) Spaulding & Schrenk, *Science, Ser. 2, 17*: 751, 1903 (A)
anamorph *Colletotrichum gloeosporioides* (Penzig) Penzig & Saccardo, *Atti Ist. veneto Sci., Ser. 6, 2*: 670, 1884
*on *Pseudopanax chathamicus* Kirk (PDD 52045).
Leaf spot. Circular brown lesions, becoming pale, up to 5 mm diam. Only the anamorph was present.

Grandinia ocellata Fries (Saccardo 1888) = *Phlebia livida* (Fries) Bresadola

Gyrothrix circinata (Berkeley & Curtis) Hughes, *Can. J. Bot. 36*: 771, 1958 (D)
on *Cyathodes robusta* Hook. f. (PDD 49403).
on *Dracophyllum arboreum* Ckn. (PDD 49405).

on *Myrsine chathamica* F. Muell. (PDD 49404).
Saprophytic on fallen leaves.

Gyrothrix citricola Pirozynski, *Mycol. Pap. 84*: 19, 1962 (D)
on *Dracophyllum arboreum* Ckn. (PDD 49406).
on *Myrsine chathamica* F. Muell. (PDD 49407).
Saprophytic on fallen leaves.

Gyrothrix podosperma (Corda) Rabenhorst, *Deut. Kryptfl. 1*: 72, 1844 (D)
on *Rhopalostylis sapida* Wendl. & Drude (PDD 49402).
Saprophytic on fallen leaves. This species was previously unknown in New Zealand.

Gyrothrix verticiclada (Goidanich) Hughes & Pirozynski, *N. Z. Jl Bot. 9*: 42, 1971 (D)
on *Myrsine chathamica* F. Muell. (PDD 49408).
Saprophytic on fallen leaves.

Hendersonia phormii Naito, *Sci. Rep. Kagoshima Univ. 1*: 77, 1952 (D)
on *Phormium tenax* J. R. & G. Forst. (PDD 44066).
Leaf spot. Elliptical lesions, up to 10 x 2 mm, reddish or purple coloured on upper surface, dark brown to black on lower surface of leaf.

Hirneola polytricha (Montagne) Fries (Saccardo 1888) = *Auricularia polytricha* (Montagne) Saccardo

Hygrocybe sp. (B)
on ground (PDD 44589).

Idriella vandalurensis Vittal, *Curr. Sci. 39*: 520, 1970 (D)
on *Dracophyllum arboreum* Ckn. (PDD 49410).
on *Myrsine chathamica* F. Muell. (PDD 49408).
Saprophytic on fallen leaves. This species was previously unknown in New Zealand.

Iodosphaeria ripogoni Samuels, Müller & Petrini, *Mycotaxon 28*: 490, 1987 (A)
anamorph *Selenosporella* sp. and *Ceratosporium* sp.
on *Ripogonum scandens* J. R. & G. Forst. (PDD 47872); (Samuels et al. 1987 - Holotype).
Saprophytic on dead stems. Known also from one collection in Taranaki.

Kuehneola uredinis (Link) Arthur, *Res. Sci. Congr. Bot. Vienne*: 342, 1905 (B)
on *Rubus fruticosus* L. (PDD 44120 - II).
Stem rust. Widespread throughout New Zealand.

Lopharia cinerascens (Schweinitz) G. H. Cunningham, *Trans. R. Soc. N. Z. 83*: 622, 1956 (B)
(Cunningham 1952 - Chatham Islands, Travers, No. 7 - filed at Kew as *Stereum subporiferum* Berk.); (Cunningham 1963 - Chatham Islands, Travers No. 7).
Fruitbody effused-reflexed. Common and widespread in New Zealand on bark or dead wood. Cunningham (1952) regarded this specimen as a *Peniophora*, but later included it as *L. cinerascens* (Cunningham 1963).

Lophodermium gramineum (Fries) Chevallier, *Fl. gén. env. Paris 3*: 435, 1826 (A)
on *Hierochloe redolens* (Vahl) Roem. & Schult. (PDD 49369); (Johnston 1989).
Saprophytic on dead leaves. Widespread and common throughout New Zealand on both indigenous and introduced grasses.

Lycoperdon caelatum Bulliard = *Calvatia utriformis* (Bulliard) Jaap

Marasmius sp. (aff. *Strobilurus*) (B)
on leaf litter (PDD 43944).

Melampsora euphorbiae (Schubert) Castagne, *Obs. Pl. Acotyl. 2*: 18, 1843 (B)
on *Euphorbia peplus* L. (PDD 43895 - II, III).
Rust. Common and widespread in New Zealand.

Melampsora hypericorum Winter in Rabenhorst, *Krypt. Fl. Ed. 2, 1(1)*: 241, 1882 (B)
on *Hypericum androsaemum* L. PDD 14191; (Baker 1956 - Te Whanga Lagoon, Te One, May 1954, E. A. Madden). Details filed with specimen give - 'collected 5 Feb 1954, E. A. Madden specimen No. 91'.
Rust. Widespread on this host throughout New Zealand.

Metacapnodium moniliforme (Fraser) Hughes, *Mycologia 68*: 709, 1976 (A)
on *Myrsine chathamica* F. Muell. PDD 19116 - Te Whanga Lagoon, 5 Nov 1959, leg. N. T. Moar (1553).
Sooty mould. Widespread and common throughout New Zealand on trees, shrubs and ferns.

Mycena austrororida Singer, *Ark. Bot. Ser. 2, 4, Hafte 5*: 394, 1962 (B)
on wood (PDD 44577, 44578, 44582).
This agaric is known on rotting wood and debris from Argentina, Chile, and throughout the North Island of New Zealand. It was initially described from New Zealand as *M. veronicae* Stevenson.

Mycena sp. (B)
among moss (PDD 44579).
on wood (PDD 44584).

Mycosphaerella brassicicola (Duby) Oudemans, *Rév. Champ. Pays-Bas 2*: 210, 1897 (A)
on *Brassica oleracea* L. var. *capitata* L. (PDD 46728).
Mycosphaerella ring spot. This disease is common on *Brassica* spp. in New Zealand. Spots become almost black with the formation, often in concentric zones, of numerous ascomata.

Mycosphaerella killianii Petrak, *Ann. mycol. 39*: 324, 1941 (A)
anamorph *Polythrincium trifolii* Kunze, *Syst. mycol. 3*: 368, 1832
on *Trifolium repens* L. (PDD 44080).
Black or sooty blotch of clovers. Black fungal colonies on lower surface of leaves. Widespread throughout New Zealand.

Mycosphaerella sp. (A)
*on *Hydrocotyle heteromeria* A. Rich. (PDD 52063).
Leaf blotch. Black ascomata scattered over leaf.

Nectria tasmanica Berkeley, *Fl. Tasman. 2*: 279, 1860 (A)
anamorph *Cylindrocarpon* sp.
(Lloyd 1924 - sent by E. F. Northcroft).
Gregarious ascomata on a small brown stroma, 2-6 mm diam. Common and widespread throughout New Zealand on plant debris.

Oidium sp. (D)
on *Plantago major* L. (PDD 44056).
*on *Plantago raoulii* Decne (PDD 44144).
on *Solanum* cf. *aviculare* Forst. f. (PDD 52046).
on *Urtica australis* Hook. f. (PDD 46730).
Powdery mildew.

Omphalina sp. (B)
on *Sphagnum* sp. (PDD 44591).
on peat (PDD 44588).
on rotting wood (PDD 44590).

Panaeolina sp. (B)
on soil (PDD 44593).

Panaeolus sp. (B)
on dung (PDD 44592).
in pasture (PDD 44587).

Periconiella phormi M. B. Ellis, *Mycol. Pap. 111*: 13, 1967 (D)
on *Phormium tenax* J. R. & G. Forst. (PDD 43930).
Purple leaf blotch. This indigenous fungus is widespread throughout New Zealand on *P. tenax* and *P. cookianum* Le Jolis.

Phellinus cf. **endapalus** (Berkeley) G. H. Cunningham, *Bull. N. Z. Dep. scient. ind. Res. 164*: 237, 1965 (B)
on dead wood (PDD 44729).
Polypore bracket fungus. Large fruitbodies, up to 20 cm diam. and 2 cm thick, occur on dead wood. Widespread and common in New Zealand on many woody hosts.

Phellinus pomaceus (Persoon) Maire, *Publ. Junta Cienc. Nat. Barcelona, Treb. Mus. Cienc. Nat. Barcelona 15(2)*: 37, 1933 (B)
(Lloyd 1924 - as *Fomes pomaceus* - sent by E. F. Northcroft).
P. pomaceus is a northern hemisphere fungus, and its occurrence in Chatham Islands would seem unlikely. According to Cunningham (1965), Lloyd's records of this species from Australia and New Zealand were mostly based on specimens of *P. zealandicus* (Cooke) G. H. Cunn.

Phlebia livida (Fries) Bresadola, *Atti Accad. Sci. Lett. Arti Ag. Ser. 3, 3*: 105, 1897 (B)
on rotten wood (Cooke 1892a); (Saccardo 1888 - as *Grandinia ocellata* - locality cited as 'Chetam Island Australiae').
Fruitbody effused. Common and widespread in New Zealand on bark and dead wood.

Pholiota sp. (B)
on wood (PDD 44583).

Phragmidium acaenae G. H. Cunningham, *Trans. N. Z. Inst. 55*: 18, 1924 (B)
*on *Acaena novae-zelandiae* Kirk (PDD 47784 - II, III).

Rust. There are four indigenous *Phragmidium* spp. on *Acaena* in New Zealand. A second collection of rust (PDD 47783) on *A. novae-zelandiae* had only uredinia present, and could not be assigned to any of the four rust species. *P. acaenae* has been recorded in the Wellington region and in the South Island on three *Acaena* spp. *P. novae-zelandiae* G. H. Cunn. was previously the only rust known on *A. novae-zelandiae.*

Phragmidium* cf. *tuberculatum J. Müller, *Ber. dt. Bot. Ges. 3*: 391, 1885 (B)
on *Rosa* sp. cult. (PDD 44082 - II, III, 44108 - II, III).
Rose rust. Common throughout New Zealand. Laundon (1970) suggested that the rust on cultivated roses in New Zealand is *P. tuberculatum*, while that on *R. eglanteria* L. is *P. mucronatum* (Pers.) Schlecht. These two species can be differentiated by aeciospore characteristics, but only uredinia and telia were present in the Chatham Islands collections.

Phyllosticta sp. (D)
*on *Corynocarpus laevigatus* J. R. & G. Forst. (PDD 46732).
Large leaf spot. This disease has also been found in Auckland.

Physalacria stilboidea (Cooke) Saccardo, *Syll. Fung. 9*: 256, 1891 (B)
on *Pseudopanax chathamicus* Kirk (PDD 52047); PDD 250 - leg. L. Cockayne, 1908.
Small, stalked, pale yellow fruitbodies up to 1 mm high, head 0.5 mm diam., on dead fallen leaves. Described from New Zealand, and occurs throughout the country on *Pseudopanax* spp.

Pleurotopsis longinqua (Berkeley) Horak, *Aust. J. Bot. Suppl. 10*: 7, 1983 (B)
on living wood (PDD 44581).
This agaric, which fruits on wood, is known also from Australia and South America.

Polyporus adustus Willdenow (Lloyd 1924) = *Bjerkandera adusta* (Willdenow) P. Karsten

Polyporus hirsutus Wulfden = *Trametes hirsuta* (Wulfden) Pilát

Polyscytalum sp. (D)
on *Cyathodes robusta* Hook. f. (PDD 49417).
Saprophytic on fallen leaves.

Pseudocercospora atromarginalis (Atkinson) Deighton, *Mycol. Pap. 140*: 139, 1976 (D)
on *Solanum* cf. *aviculare* Forst. f. (PDD 50790).
Leaf blotch. The fungus is widespread in New Zealand, especially on *Solanum nigrum* L.

Pseudopeziza medicaginis (Lib.) Saccardo, *Malpighia 1*: 454, 1887 (A)
*on *Medicago lupulina* L. (PDD 43937, 44053, 44064).
Leaf spot. Small lesions <1 mm diam., black, irregularly-shaped, most noticeable on upper surface of leaflets. Apothecia erumpent within larger spots. Common and widespread on *Medicago* spp. in New Zealand.

Pseudopeziza trifolii (de Bivona-Bernardi) Fuckel, *Jb. nassau Ver. Naturk. 2*: 290-1, 1870 (A)
*on *Trifolium cernuum* Brot. (PDD 44172).
Leaf spot. Small lesions <1 mm diam., brown, irregularly-shaped. Apothe-

cia erumpent within larger spots. Common and widespread on *Trifolium* spp. in New Zealand.

Puccinia antirrhini Dietel & Holway, *Hedwigia 36*: 298, 1897 (B)
on *Antirrhinum majus* L. (PDD 44122 - II, III).
Rust. Common on antirrhinum in New Zealand, and also occurs on *Linaria macroccana* Hook. f.

Puccinia aucta Berkeley & F. Müller, *J. Linn. Soc. Bot. 13*: 173, 1872 (B)
on *Lobelia anceps* Linné f. (PDD 44157 - III).
Rust. This indigenous species is widespread on *L. anceps* in New Zealand.

Puccinia brachypodii Otth var. ***poae-nemoralis*** (Otth) Cummins & H. C. Greene, *Mycologia 58*: 705, 1966 (B)
on *Anthoxanthum odoratum* L. (PDD 43915 - II).
on *Poa annua* L. (PDD 44057 - II, 44058 - II).
Rust. Common and widespread on several introduced grasses, and on the endemic *Hierochloe novae-zelandiae* Gandoger, in New Zealand.

Puccinia calcitrapae var. ***calcitrapae*** de Candolle, *Fl. Fr. 2*: 221, 1805 (B)
on *Carduus tenuiflorus* Curtis (PDD 44152 - III).
Rust. Common and widespread on *Carduus* spp. in New Zealand.

Puccinia caricina de Candolle, *Fl. Fr. 6*: 60, 1815. (B)
on *Carex lessoniana* Steud. (PDD 44230 - II).
*on *Carex ternaria* Boott (PDD 44225 - II, III).
*on *Carex ventosa* C. B. Clarke (PDD 44227 - II, III).
on *Carex virgata* Boott (PDD 44226 - II).
Rust. This introduced species is widespread on indigenous *Carex* spp. in New Zealand. Cunningham (1931) recorded *C. ternaria* as a host, with records from Tirau, Seatoun and Wakatipu. However, *C. ternaria* occurs only in the Chatham Islands, Antipodes Islands and Auckland Islands. The hosts for the collections cited by Cunningham have been redetermined as *C. coriacea* Hamlin and *C. geminata* Schkuhr.

Puccinia cockaynei G. H. Cunningham, *Trans. N. Z. Inst. 54*: 670, 1923 (B)
*on *Gentiana chathamica* Cheesem. (PDD 44084 - II).
Rust. This endemic species infects several *Gentiana* spp. in the South Island.

Puccinia coronata Corda, *Icon. fung. 1*: 6, 1837 (B)
on *Agrostis capillaris* L. (PDD 44255 - II, III).
on *Agrostis stolonifera* L. (PDD 44182 - II, III).
on *Avena fatua* L. (PDD 43894 - II, 43929 - II, III).
on *Dactylis glomerata* L. (PDD 43901 - II).
on *Holcus lanatus* L. (PDD 43928 - II, 44077 - II).
on *Lolium perenne* L. (PDD 43897 - II).
Crown rust. Common and widespread on many different grasses in New Zealand.

Puccinia crepidicola H. & P. Sydow, *Ost. bot. Z. 51*: 17, 1901 (B)
*on *Crepis capillaris* (L.) Wallr. (PDD 43911 - II, III, 43913 - II).
Rust. The Chatham Islands collections were the first record of this species in New Zealand. Since then it has become common and widespread through-

out the country. Elsewhere, several species of *Puccinia* have been recorded on *Crepis*. The absence of aecia in the New Zealand specimens, and the host species, suggests that the local collections are *P. crepidicola*. Teliospores of the New Zealand collections are slightly larger than those of British collections - 26-44 x 23-29 μm versus 30-36 x 22-26 μm (Wilson & Henderson 1966).

Additional specimens examined:
Auckland, Mt Albert, 19.V.1983, E. H. C. McKenzie (PDD 44480 - II); Mt Albert, 13.III.1984, E. H. C. McKenzie (PDD 45178 - II, III). Hawkes Bay, Turangakumu, 26.III.1984, E. H. C. McKenzie (PDD 45088 - II). Mid Canterbury, Christchurch, Riccarton, 8.XII.1984, A. J. Healy (PDD 46742 - II); Riccarton, 20.XII.1988, A. J. Healy (PDD 55612 - II). Mackenzie, Lake Tekapo, June 1987, D. Scott (PDD 45623 - II).

Puccinia crinitae McNabb, *Trans. R. Soc. N. Z. 1*: 241, 1962 (B)
on *Dichelachne crinita* (Linné f.) Hook. f. (PDD 43920 - II).
Leaf rust. Occurs throughout New Zealand, but restricted to *D. crinita*.

Puccinia graminis Persoon, *Syn. meth. Fung.*: 228, 1801 (B)
on *Critesion murinum* (L.) Löve (PDD 44177 - II).
on *Dactylis glomerata* L. (PDD 43899 - II, 43919 - II).
on *Lolium perenne* L. (PDD 43917 - II, 43918 - II, III, 44078 - II).
Stem rust. Common and widespread on many different grasses and cereals in New Zealand.

Puccinia hieracii (Röhling) Martius var. ***hieracii***, *Prodr. fl. mosq. Ed. 2*: 226, 1817 (B)
on *Taraxacum officinale* Wiggers (PDD 43912 - II, III).
Leaf rust. This species has become common on *T. officinale* since it was first observed in New Zealand on this host in 1978.

Puccinia hordei Otth, *Mitth. Naturf. Ges. Bern 1870*: 114, 1871 (B)
on *Critesion murinum* (L.) Löve (PDD 44131 - II, III).
Barley rust. Common and widespread on barley grasses in New Zealand.

Puccinia juncophila Cooke & Massee, *Grevillea 22*: 37, 1893 (B)
on *Juncus pallidus* R. Br. (PDD 44184 - II, III).
Rust. This indigenous species is widespread on *Juncus* spp. in New Zealand.

Puccinia malvacearum Montagne, *Hist. Fis. Polit. Chili 8*: 43, 1852 (B)
on *Malva neglecta* Wallr. (PDD 44155 - II).
Rust. Common and widespread on species of *Althaea, Lavatera* and *Malva* in New Zealand.

Puccinia oxalidis Dietel & Ellis, *Hedwigia 34*: 291, 1895 (B)
on *Oxalis articulata* Savigny (PDD 45328 - II).
Oxalis rust. This fungus has become common on *Oxalis* spp. since it was first observed in New Zealand in 1977.

Puccinia pelargonii-zonalis Doidge, *Bothalia 2*: 98, 1926 (B)
on *Pelargonium* x *hortorum* Bailey (PDD 44051 - II).
Rust. Widely distributed with the host in New Zealand.

Puccinia recondita Roberge ex Desmazières, *Bull. Soc. bot. Fr. 4*: 798, 1857 (B)
on *Bromus mollis* L. (PDD 43908 - II, 43909 - II).
on *Elymus rectisetus* (Nees) Löve & Connor (PDD 45177 - II, III).
on *Elytrigia repens* (L.) Nevski (PDD 44181 - II, III).
Brown rust or leaf rust. Common and widespread on many grasses and cereals in New Zealand.

Puccinia tenuispora McAlpine, *Rusts of Australia*: 137, 1906 (B)
*on *Luzula banksiana* Meyer var. *acra* Edgar (PDD 45189 - II, 45190 - II, III).
Rust. This indigenous species is restricted to *Luzula* spp. in New Zealand and Australia.

Puccinia tetragoniae McAlpine var. ***novae-zelandiae*** McKenzie, ined. (B)
on *Tetragonia tetragonioides* (Pallas) Kuntze (PDD 56064 - 0, II, III).
Rust. Common and widespread on *T. tetragonioides* and *T. trigyna* Banks & Sol. ex Hook. f. in the North Island. Previously recorded in New Zealand as *Uredo novae-zelandiae* Laundon (1963).

Pucciniastrum pustulatum Dietel in Engler & Prantl, *Nat. Pflanzenfam. 1*: 47, 1888 (B)
*on *Epilobium alsinoides* A. Cunn. (PDD 44153).
Rust. This introduced species has been recorded on several endemic *Epilobium* spp. in the North Island, and is common on cultivated *Fuchsia*.

Pyrenophora avenae Ito & Kuribayashi in Ito, *Proc. imp. Acad. Japan 6*: 354, 1930 (A)
anamorph *Drechslera avenae* (Eidam) Scharif, *Studies on graminicolous species of* Helminthosporium, *Teheran*: 72, 1963
on *Dichelachne crinita* (Linné f.) Hook. f. (PDD 43932, 44075).
on *Hierochloe redolens* (Vahl) Roem. & Schult. (PDD 43935).
Causes leaf spot and seedling blight of oats in New Zealand. Found mainly on senescing leaves of the two grasses in Chatham Islands. Only the anamorph was present. It has also been found on *D. crinita* at Woodhill, near Auckland (PDD 36455).

Pyrenophora dictyoides Paul & Parbery, *Trans. Brit. mycol. Soc. 51*: 708, 1968 (A)
anamorph *Drechslera dictyoides* (Drechsler) Shoemaker, *Can. J. Bot. 37*: 881, 1959
on *Dactylis glomerata* L. (PDD 43902).
Found on senescing leaves. Only the anamorph was present. Previously recorded on cocksfoot seed in New Zealand (McKenzie 1978), and causing net blotch of ryegrasses (Latch 1966).

Pyrenophora graminea Ito & Kuribayashi in Ito, *Proc. imp. Acad. Japan 6*: 353, 1930 (A)
anamorph *Drechslera graminea* (Rabenhorst ex Schlechtendal) Shoemaker, *Can. J. Bot. 37*: 881, 1959
*on *Critesion murinum* (L.) Löve (PDD 44174).
Leaf stripe. Only the anamorph was present. First identified in New Zealand, on barley, in 1975 (Arnst et al. 1978).

Pyrenophora teres Drechsler, *J. agric. Res. 24*: 656, 1923 (A)
anamorph *Drechslera teres* (Saccardo) Shoemaker, *Can. J. Bot. 37*: 881, 1959
on *Critesion murinum* (L.) Löve (PDD 43916, 44046).
Net blotch. Only the anamorph was present. This disease became prevalent and destructive in New Zealand on barley following the withdrawal of organomercury seed treatments (Arnst 1976).

Ramaria abientina (Persoon) Quélet, *Fl. mycol. Fr.*: 467, 1888 (B)
PDD 35847 - leg. H. H. Travers, 1872, No. 21 (No. 144); MEL - labelled *Clavaria abientina* Scham., 1872, leg. H. H. Travers No. 21 (No. 144); K - D. A. Reid, pers. comm. - filed as *Clavaria abientina*.
R. abientina is a northern hemisphere fungus and the determination of the Chatham Islands fungus must be queried. An early Australian record of this fungus is in doubt (Corner 1950), and the species is not listed by Petersen (1988) in his treatment of clavarioid fungi of New Zealand.

Ramularia holci-lanati (Cavara) Deighton, *Trans. Br. mycol. Soc. 59*: 190, 1972 (D)
on *Holcus lanatus* L. (PDD 43914).
Leaf spot. Common throughout the year. Occurs naturally only on *H. lanatus*.

Ramularia rubella (Bonorden) Nannfeldt in Lundell & Nannfeldt, *Fung. Exsicc. Suec. No. 1992*: 1950 (D)
*on *Rumex conglomeratus* Murray (PDD 44175).
on *Rumex* sp. (PDD 44076).
Ramularia leaf spot. Common on *Rumex* spp. throughout New Zealand.

Rosenscheldiella sp. (A)
*on *Olearia traversii* (F. Muell.) Hook. f. (PDD 44011).
Scattered, superficial, black ascomata on lower surface of leaves, surrounded by rust-coloured discoloration of leaf hairs.

Schizophyllum commune Fries, *Syst. mycol. 1*: 330-1, 1821 (B)
on wood MEL - H. H. Travers No. 3 (No. 51); (Saccardo 1887 - as *Schizophyllum multifidum* (Batsch) Fr.); (Cooke 1892a - as *Schizophyllum commune* Fr. var. *multifidum* Fr.).
Small white, fan-shaped, feathery bracket fructifications occur singly or in groups on wood. Common throughout New Zealand as a saprophyte and occasional wound pathogen.

Schizophyllum commune Fries var. ***multifidum*** (Cooke 1892a) = *Schizophyllum commune* Fries

Schizophyllum multifidum (Batsch) Fries (Saccardo 1887) = *Schizophyllum commune* Fries

Septoria antirrhini Roberge & Desmazières, *Annls Sci. nat. Bot. Sér. 3, 20*: 87, 1853 (D)
on *Antirrhinum majus* L. (PDD 44123).
Septoria leaf spot.

Septoria sp. (D)
*on *Deyeuxia* sp. (PDD 52051).
*on *Muehlenbeckia australis* (Forst. f.) Meissn. (PDD 52048).
*on *Sonchus oleraceus* L. (PDD 52049, 52050).

Leaf spot.

Sphaerodothis danthoniae (McAlpine) Walker & Francis, *Trans. Br. mycol. Soc. 69*: 151, 1977 (A)
on *Rytidosperma unarede* (Raoul) Connor & Edgar (PDD 43921, 43926, 43927).
Tar spot on leaves. Indigenous to New Zealand and Australia.

Sphaerotheca fuliginea (Schlechtendal) Pollacci, *Atti Ist. bot. Univ. Pavia Ser. 2, 2*: 8, 1905 (A)
on *Calendula officinalis* L. (PDD 46734).
Powdery mildew. Common and widespread on *Calendula* in New Zealand.

Stereum complicatum Fries, *Epicr.*: 548, 1838 (B)
(Cunningham 1952 - Chatham Islands, N. Z., Travers - filed at Kew as *Stereum hirsutum* Cooke).
Bracket fungus. Widespread and common in New Zealand on dead branches of a wide range of plants. Cunningham (1952) redetermined the specimen from Chatham Islands as *S. rameale* (Schwein.) Massee, a species which does not occur in Australasia. He later treated the New Zealand species as *S. complicatum* (Cunningham 1963).

Stereum concolor Berkeley (Lloyd 1924) = *Stereum fasciatum* (Schweinitz) Fries

Stereum fasciatum (Schweinitz) Fries, *Epicr.*: 546, 1838 (B)
(Lloyd 1924 - as *Stereum concolor* - sent by E. F. Northcroft).
Bracket fungus. Widespread and common in New Zealand on dead branches and trunks of a wide range of plants.

Stereum hirsutum (Willdenow) Persoon, *Rom. Mag. Bot. 1*: 110, 1794 (B)
on wood (PDD 44745).
Bracket fungus. Widespread in New Zealand on wood and dead branches.

Stereum miquelianum Montagne, *Tijdschr. Wis. Natuurk. Wetensch. Amsterdam 4*: 203, 1851 (B)
(Lloyd 1924 - sent by E. F. Northcroft).
According to Cunningham (1963) the description of this species is inadequate and there is no extant type specimen. Cunningham suggests that Lloyd's record is based on specimens of *S. elegans* (Meyer) Fr. or *S. affine* Lév.

Stereum rameale (Schweinitz) Massee (Cunningham 1952) = *Stereum complicatum* Fries

Stereum vellereum Berkeley in J. D. Hooker, *Fl. Novae-Zelandiae 2*: 183, 1855 (B)
on *Dracophyllum arboreum* Ckn. (PDD 44732, 44733); (Lloyd 1924 - sent by E. F. Northcroft).
Bracket fungus. Widespread and common in New Zealand on dead branches and twigs of a wide range of plants. Indigenous to New Zealand and Australia.

Stilbella fimetaria (Persoon) Lindau in Rabenhorst, *Kryp. Fl. 1(9)*: 301, 1910 (D)
on cat dung (PDD 46777).
Salmon-coloured synnemata up to 1 cm high on dung. Elsewhere occurs on

many kinds of dung.

Suillus granulatus (Link) O. Kuntze, *Rev. Gen. Pl. 3*: 535, 1898 (B)
under *Pinus radiata* D. Don (PDD 50134).

This mycorrhizal bolete is widespread in New Zealand growing in association with *Pinus* spp.

Thelephora terrestris Ehrhart : Fries, *Syst. mycol. 1*: 431, 1821 (B)
under *Pinus radiata* D. Don (PDD 44731).

Brown encrusting fungus. Mycelium growing over and binding pine needles, humus and soil. Common and widespread under *P. radiata* in New Zealand.

Trametes hirsuta (Wulfden) Pilát, *Atl. Champ. Europ. 3*: 265, 1939 (B)
MEL - labelled *Polyporus hirsutus* forma *abnormalis*, H. H. Travers.

Polypore bracket fungus. Saprophytic on fallen and attached dead branches. Common and widespread in New Zealand on a wide range of plants.

Uredo chathamica McKenzie, ined. (B)
*on *Carex chathamica* Petrie (PDD 44228); PDD 42220 - Chatham Island, Mahahatau Creek, J. F. Findlay, Jan 1955 (CHR 97202); PDD 42221 - Chatham Island, east of Te Whanga Lagoon, J. F. Findlay, Jan 1955 (CHR 97201); PDD 41170 - Pitt Island, B. G. Hamlin, 1 Dec 1957 (WELT 3325).
*on *Carex trifida* Cav. PDD 42218 and 42219 - Rangatira (South East Island), B. Bell, Dec 1961 (CHR 158261 and 158260).

Rust. Known only from the Chatham Islands.

Uredo karetu G. H. Cunningham, *Trans. N. Z. Inst. 55*: 41, 1924 (B)
on *Hierochloe redolens* (Vahl) Roem. & Schult. (PDD 45175, 45176).

Rust. This indigenous species was known previously only from the type collection from Bluff.

Uredo phormii G. H. Cunningham, *Trans. N. Z. Inst. 55*: 42, 1924 (B)
on *Phormium tenax* J. R. & G. Forst. (PDD 43931).

Rust. This endemic species although widespread, does not appear to be common in New Zealand. It also occurs on *P. cookianum*.

Uredo scirpi-nodosi McAlpine, *Rusts of Australia*: 202, 1906 (B)
on *Isolepis inundata* R. Br. (PDD 45171).
on *Isolepis nodosa* (Rottb.) R. Br. (PDD 44048).
on *Isolepis distigmatosa* (C. B. Clarke) Edgar (PDD 44148).

Rust. This indigenous stem rust occurs on *Isolepis* spp. throughout the North Island, and in the northern South Island.

Uredo sp. (B)
*on *Deyeuxia billardieri* Kunth (PDD 52055).

Uromyces dactylidis Otth, *Mitth. Naturf. Ges. Bern 1861*: 85, 1861 (B)
on *Dactylis glomerata* L. (PDD 44079 - II, III).

Rust. Common and widespread on cocksfoot in New Zealand. Aecia are produced on *Ranunculus repens* L.

Uromyces danthoniae McAlpine, *Rusts of Australia*: 85, 1906 (B)
on *Rytidosperma clavatum* (Zotov) Connor & Edgar (PDD 43924 - II).
on *Rytidosperma unarede* (Raoul) Connor & Edgar (PDD 43925 - II).

Rust. This indigenous species is common on *Rytidosperma* spp. in New Zealand.

Uromyces edwardsiae G. H. Cunningham, *Trans. N. Z. Inst. 55*: 392, 1924 (B)
on *Sophora microphylla* Ait. (PDD 43847 - I).
Rust. Aecia on pronounced fusiform swellings on branches. Telia, which are not present on the Chatham Islands material, are associated with galls on pods. This endemic species is widespread on *Sophora* spp. in New Zealand.

Uromyces ehrhartae McAlpine, *Agric. Gaz. N. S. W. 6*: 855, 1895 (B)
on *Microlaena stipoides* R. Br. (PDD 43922 - II).
Rust. This indigenous species is common on *M. stipoides*, and also occurs on *M. polynoda* Hook. f. in New Zealand.

Uromyces microtidis Cooke, *Grevillea 14*: 12, 1885 (B)
on *Microtis unifolia* (Forst. f.) Reichb. (Cunningham 1931).
Rust. This indigenous species is common and widespread throughout New Zealand.

Uromyces minor Schröter in Cohn, *Krypt. Flora Schles. 3*: 310, 1887 (B)
on *Trifolium dubium* Sibth. (PDD 43936).
Rust. This species is common on *T. dubium* and *T. micranthum* Viv. in New Zealand. It has also been recorded in New Zealand on *Pisum sativum* L. (Laundon 1973).

Uromyces otakou G. H. Cunningham, *Trans. N. Z. Inst. 54*: 627, 1923 (B)
*on *Poa chathamica* Petrie (PDD 52053 - II).
Rust. This endemic species is widespread on indigenous *Poa* spp. in New Zealand.

Uromyces scaevolae G. H. Cunningham, *Trans. N. Z. Inst. 61*: 413, 1930 (B)
on *Selliera radicans* Cav. (PDD 44156 - I, II, III, 46731 - II).
Rust. This indigenous species is widespread in New Zealand.

Uromyces striatus Schröter, *Abh. Schles. Ges. Vaterl. Cult., Abhth. Naturwiss. 1869-72*: 11, 1870 (B)
*on *Medicago arabica* (L.) Hud. (PDD 44063 - II).
on *Medicago lupulina* L. (PDD 43938 - II, 44060 - II).
Rust. Widespread on *Medicago* spp. including *M. sativa* L., in New Zealand.

Uromyces trifolii (Hedwig f. ex de Candolle) Fuckel, *Symb. mycol.*: 63, 1870 (B)
on *Trifolium repens* L. (PDD 44059 - III).
Rust. Common and widespread on white clover in New Zealand.

Uromyces trifolii-repentis Liro, *Bidr. Kann. Finl. Nat. Folk 65*: 94, 1908 (B)
*on *Trifolium cernuum* Brot. (PDD 46726 - III).
Rust. Common and widespread on several *Trifolium* spp. in New Zealand.

Uromyces viciae-fabae (Persoon) Schröter, *Hedwigia 14*: 161, 1857 (B)
on *Vicia sativa* L. (PDD 43896 - II, III).
Rust. Common on vetches and on *V. faba* L. in the North Island.

Ustilago bullata Berkeley in J. D. Hooker, *Fl. Novae-Zelandiae 2*: 196, 1855 (B)
on *Bromus willdenowii* Kunth (PDD 50294); (Vánky 1985 - Waitangi, 18 Feb 1983, E. H. C. McKenzie).

Ear smut. Black spore mass in spikelets replacing the flower parts. Common and widespread on *Bromus* spp. and *Elymus rectisetus* in New Zealand.

Ustilago striiformis (Westendorp) Niessl, *Hedwigia 15*: 1, 1876 (B)
on *Holcus lanatus* L. (PDD 44045, 44074).
Stripe smut. Sori in leaves and aborted inflorescences. Recorded on several grasses in New Zealand.

Vascellum pratense (Persoon) Kreisel, *Feddes Repert. nov. Spec. Regni veg. 64*: 159, 1962 (B)
on ground in pasture (PDD 44734).
Puffball. Up to 3.5 cm diam. Common in New Zealand in grassland.

Venturia rumicis (Desmazières) Winter in Rabenhorst, *Kryptfl. 1(2)*: 435, 1887 (A)
on *Rumex obtusifolius* L. (PDD 43939, 44185).
Venturia leaf spot. Occurs on *Rumex* spp. throughout New Zealand.

Xylaria plebeja Cesati, *Atti Accad. Sci. fis. mat., Napoli 8(3)*: 16, 1879 (A)
(Lloyd 1924 - sent by E. F. Northcroft).
There appears to be no other record of this tropical fungus from New Zealand.

Zygosporium minus Hughes, *Mycol. Pap. 4*: 6-7, 1951 (D)
on *Corynocarpus laevigatus* J. R. & G. Forst. (PDD 49431).
Saprophytic on fallen leaves.

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LITHOTHELIUM AUSTRALE spec. nova, A NEW LICHEN FROM NEW ZEALAND

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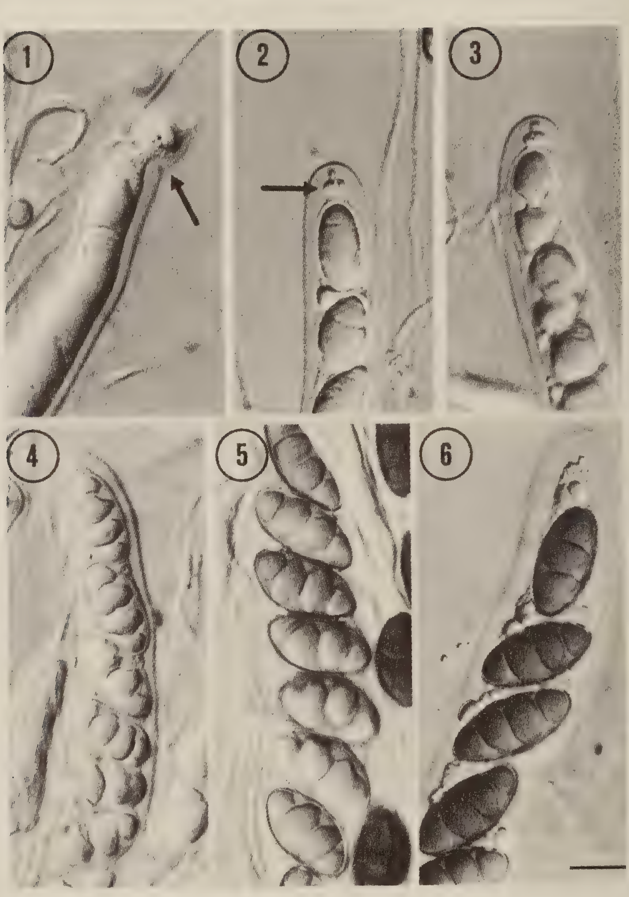
ABSTRACT: A new calcicolous species of the genus *Lithothelium* is described from Chatham Island (New Zealand). The characters of the new species are compared with other closely related taxa.

The small collection by B.P.J.MOLLOY (Christchurch) of calcicolous lichen specimens from Chatham Island includes a remarkable pyrenocarpous species. In connection with a monographic treatment of parts of the Pyrenulaceae, the first author (APTROOT) recognized the new species as belonging to the genus *Lithothelium* MÜLL.ARG. [see APTROOT (1991) and HARRIS (1989) for generic characteristics and systematic position].

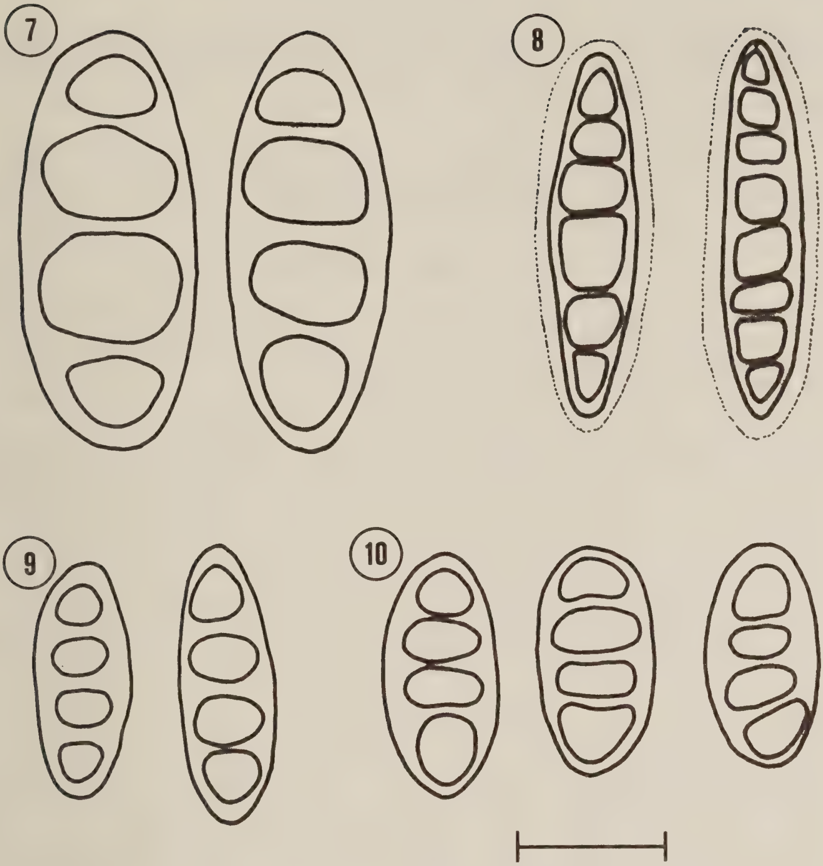
Lithothelium australe APTROOT & H.MAYRH. spec. nova

Thallus endolithicus. *Ascocarpia* aggregata, astrothelioidea. Asci 8-spori, 80-110 μm longi, 12-15 μm lati, apicibus sagittiformibus. Sporae triseptatae, rufofuscae, 20-26 μm longi, 6-8 μm lati.

TYPE: *New Zealand*: Chatham Island, "Big Bush", on loose bryozoan limestone outcrops, 40 m, II.1985, *B.P.J.MOLLOY* (CHR - holotype, BM, CHR, GZU - isotypes).



Figures 1 - 6. *Lithothelium australe* (GZU-isotype). Ascus apex and ascospore ontogeny. 1, immature ascus with fissitunicate dehiscense; 2, sagittiform ascus apex and young hyaline one-celled ascospores; 3, young ascospores with one septum; 4, hyaline immature ascospores with three septa and thickened endospore; 5, nearly mature light-brown ascospores with thickened endospore; 6, mature ascospores with reduced thickenings of the endospore; scale = 10 μm.



Figures 7 - 10. Ascospores. 7, *Lithothelium australe* (holotype); 8, *Lithothelium bahamense* (holotype); 9, *Lithothelium cubanum* (holotype); 10, *Pyrenula falklandica* (holotype); scale = 10 µm.

Thallus endolithic, photobiont probably *Trentepohlia*. *Ascocarps* simple or with fused ostioles and fused walls (astrothelioid), without pseudostromatic tissues and crystals, conical, erumpent from the substrate, exposed, 0,5-0,7 mm diam., 0,3-0,5 mm high; ascocarp wall completely carbonized, without distinct clypeus, up to 150 µm thick; ostiole brown, obconical, skewed, 100-200 µm diam.; hamathecium not inspersed, I negative; interthecial hyphae true paraphyses, branched only at the tips; periphyses absent. *Asci* fissitunicate (fig. 1), with sagittiform ocular chamber (figs. 2,3), 80-110 x 12-15 µm, 8-spored. *Ascospores* uniseriate (figs. 4,5), mature red-brown (fig. 6), fusiform with attenuated ends, 20-26 x 6-8 µm, symmetrically septate, not constricted at the septa, septa consisting of 3 distosepta, endospore thickened in immature spores (figs. 3-5), but thickenings slightly reduced in mature ones (figs. 6,7); spore wall smooth, without gelatinous sheeth. *Pycnidia* black, 100-200 µm diam., wall completely carbonized, up to 40 µm thick; spermatia acrogenous, colourless, filiform, 6-10 x 0,2-0,4 µm. *Chemistry:* no substances detected by TLC.

Lithothelium australe is the only saxicolous species of the genus with brown ascospores. It is closely related to *Lithothelium bahamense* RIDDLE, *Lithothelium cubanum* MÜLL.ARG. and to *Pyrenula falklandica* (NYL.)ZAHLBR., a species which also belongs in *Lithothelium* (APTROOT 1991). However these three taxa all possess colourless ascospores. The new species is particularly interesting because of its implications for the separation of *Plagiocarpa* HARRIS and *Lithothelium* MÜLL.ARG. s.str., combining the fused ascocarps of *Lithothelium* with the characteristic red-brown ascospores of *Plagiocarpa.*

DISTRIBUTION: The new species is only known from the type specimens on bryozoan limestone in Chatham Island. The locality "Big Bush" refers to an area formerly covered in forest. But most of this has been eliminated. *Lithothelium australe* is associated with *Bacidia* sp., *Caloplaca* sp., *Diploicia canescens* s.l., *Mycobilimbia lobulata* (different ecotype), *Physcia adscendens, Toninia aromatica* and *Xanthoria parietina.* According to GALLOWAY (1985) all these species are previously unrecorded for Chatham Island. *Mycobilimbia lobulata* is a new record for the region.

ACKNOWLEDGEMENTS

We are indebted to Dr B.P.J.MOLLOY (Christchurch) for collecting and arranging the loan of the material, Dr E.TIMDAL (Oslo) for the identification of the *Toninia,* Dr J.HAFELLNER (Graz) for the confirmation of the *Mycobilimbia,* Dr G.KANTVILAS (Hobart) for correcting the English text, Dr C.D.MEURK (Christchurch) for valuable comments, and last but not least to Dr W.WETSCHNIG (Graz) for his kind assistance on the word-processor. The investigations (APTROOT) were supported by the Foundation for Biological Research (BION), which is subsidized by the Netherlands Organisation for Scientific Research (NWO).

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NEW SPECIES AND NEW REPORTS OF PERTUSARIA (LICHENISED ASCOMYCOTINA) FROM AUSTRALIA AND NEW ZEALAND WITH A KEY TO THE SPECIES IN AUSTRALIA

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ABSTRACT: The species *Pertusaria atropunctata* Archer, *Pertusaria confusa* Archer, *Pertusaria epacrospora* Archer, *Pertusaria errinundrensis* Archer, *Pertusaria hermaka* Archer, *Pertusaria isidiosa* Archer, *Pertusaria lacericans* Archer, *Pertusaria miscella* Archer, *Pertusaria norstictica* Archer, *Pertusaria paragibberosa* Archer, *Pertusaria patellifera* Archer, *Pertusaria pseudodactylina* Archer, *Pertusaria remota* Archer, *Pertusaria scaberula* Archer, *Pertusaria sordida* Archer, *Pertusaria subisidiosa* Archer, *Pertusaria sublacerans* Archer, *Pertusaria subrhodotropa* Archer, *Pertusaria thiophaninica* Archer, *Pertusaria thula* Archer, *Pertusaria trachyspora* Archer, *Pertusaria trevethensis* Archer, *Pertusaria vulpina* Archer, *Pertusaria wilsonii* Archer and *Pertusaria xanthosorediata* Archer are described as new. *Pertusaria commutata* Müll.Arg. *Pertusaria consanguinea* Müll.Arg., *Pertusaria dehiscens* Müll.Arg., *Pertusaria lacerans* Müll.Arg., *Pertusaria leioplacella* Nyl. and *Pertusaria subventosa* Malme are reported from Australia and *Pertusaria xanthostoma* (Somm.) Fr. is reported from Australia and New Zealand. Lectotypes are chosen for *Pertusaria aggregata* Müll.Arg., *Pertusaria commutata* Müll.Arg. and *Pertusaria consanguinea* Müll.Arg. A key to the named species of *Pertusaria* in Australia is presented.

Introduction

The lichen genus *Pertusaria* in Australia has received little systematic study. Many new taxa from Australia were described by J. Müller (Müller Argoviensis) and others in the late 19th. century and these have recently been revised (Archer 1991); seven new taxa have also been described (Archer 1990; Kantvilas 1990; Elix, Streimann & Archer 1991). A study of several recent collections of the genus, particularly from eastern Australia, together with older herbarium specimens, has revealed a number of undescribed taxa which are reported here. The new taxa are differentiated from known taxa on the basis of spore morphology and number, and chemistry; thallus morphology is considered to be of less diagnostic value as differences in the appearance of thalli often merely reflect differences in the surface structure of the substrate.

The material examined consisted of specimens from AD, ANUC, BRIU, CBG, GZU, H, HO, MEL, NSW, PERTH, S and WELT and from the herbaria of J. A. Elix, W. Ewers, J. Hafellner, K. Kalb, G. Kantvilas, H. T. Lumbsch, H. Mayrhofer, R. W. Rogers, G. N. Stevens, H. Streimann and D. Verdon. All type specimens cited here have been examined unless otherwise indicated. Sections of verrucae were mounted in water for measurement of spore size; the spore dimensions quoted are those of mature spores although smaller, immature spores may also be present. The spore descriptions follow the nomenclature of Dibben (1980:10). Thin-layer chromatography was carried out on acetone extracts using the mobile phases A and C of Culberson (1972) and the compounds were detected with UV light, sulphuric acid (Culberson 1972) and MBTH (Archer 1978). Perlatolic acid and related compounds were separated with an alkaline mobile phase (Archer 1987) and differentiated with MBTH. The chemistry of the majority of the specimens from ANUC was determined by the Chemistry Department, Australian National University.

The figures illustrate holotypes except for *P. atropunctata* which is KALB 18901.

Pertusaria atropunctata Archer sp.nov. Figure 1

Thallus griseo-albus, areolatus et rimosus, superficies hebetata, sorediis et isidiis destitutus, corticola; apothecia verruciformia, thallo concoloria, complanato-hemisphaerica vel immersa, 0.5-1 mm diam.; ostiola conspicua, nigra, in verrucis 1-4na, coalescentia et discum irregularem anthracinum pseudolecideinum formantia, 0.3-0.6 mm diam.;sporae 2nae, uniseriatae, elongato-ellipsoideae, laeves, 85-100 µm longae, 30-40 µm latae.

Materia chemica in thallo non detecta.

Type: Australia, New South Wales, Buckenbowra River estuary, 7.5 km W of Batemans Bay, 35°42´S, 150°06´E, on *Avicennia marina, J.A.Elix 11004,* 29.v.1983; ANUC-holotype; *K.Kalb 18757, 18901,* 4.vi.1988; herb KALB-topotypes.

Thallus greyish white, areolate and cracked, surface dull, lacking soredia and isidia, corticolous; *apothecia* verruciform, flattened hemispherical to immersed, concolorous with the thallus, 0.5-1 mm diam.; ostioles conspicuous, black, 1-4/verruca, fusing to form an irregular, black, pseudolecideine disc, 0.3-0.6 mm diam.; *spores* 2/ascus, uniseriate, elongate-ellipsoid, smooth, 85-100 µm long, 30-40 µm wide.
Chemistry: K-, KC-, C-, Pd-; no lichen compounds detected by thin-layer chromatography.

P. atropunctata superficially resembles some species of *Lecidea* but is readily distinguished from species in that genus by the large, double-walled spores in contrast to the smaller (10-20 µm) single walled spores in *Lecidea*. In spite of considerable collecting along the coast of eastern Australia, *P. atropunctata* is known only from the three specimens from the locality listed above, where it grows on mangroves.

Pertusaria confusa Archer sp. nov. Figure 2

Thallus albidus vel flavido-albus, rugosus et rimosus, sorediis et isidiis destitutus, corticola; apothecia disciformia, numerosa et conferta, adnata, marginibus thallo concoloris, disci rotundati, 0.5-1.5 mm diam., plani, albo-pruinosi; asci clavati, raro fertiles; sporae singulae, sublachrymiformes vel elongatae-ellipsoideae, laeves, 110-160 µm longae, 30-55 µm latae, parietibus *ca.* 1 µm crassis.
Thallus lichexanthone et acidum picrolichenicum continens.

Type. Australia, Queensland, Clarke Range, 46 km SSW of Proserpine, 600 m, in rain forest on *Argyrodendron trifoliatum,* 20°49´S, 148°29´E, *H. Streimann 37465,* 29.vi.1986; CBG-holotype; B-isotype.

Thallus off-white to pale yellowish white, wrinkled and cracked, lacking isidia and soredia, corticolous; *apothecia* disciform, numerous and crowded, adnate or rarely slightly stipitate, margin concolorous with the thallus, disc round, somewhat sunken, 0.5-1.5 mm diam., flat, white pruinose; asci clavate, rarely fertile; *spores* 1/ascus, sublachrymoid to elongate-ellipsoid, smooth, 110-160 µm long, 30-55 µm wide, spore wall *ca.* 1 µm thick. *Chemistry:* K-, KC+ violet, C-, Pd-; lichexanthone and picrolichenic acid and picrolichenic acid homologue, Rf(C) 26.

Specimens examined.
QUEENSLAND. North Stradbroke Island, near Myora Springs, on bark of *Bruguiera*, sea-level, *R. Rogers & G. N. Stevens 565*, 21.ii.1975 (BRIU); Hinchinbrook Island, on *Rhizophora*, sea-level, *G. N. Stevens 3925*, 22.vii.1979 (BRIU); Weyba Creek, SW of Noosa Heads, on mangrove, sea-level, *J. Hafellner 17952*, 27.vii.1986 (GZU); Noosa River NE of Tewantin, on *Rhizophora*, sea-level, *J. Hafellner 19229*, 27.vii.1986 (GZU); Mt. Mee State Forest, about 1 km NW of forest station, rain forest, 500 m, *J. Hafellner 16884*, 13.viii.1986 (GZU).
NEW SOUTH WALES. Cowan Creek, site of Duffys Wharf, ca. 25 km N of Sydney, on *Casuarina*, sea-level, *A. Archer P 90A*, 20.1.1990 (NSW); Buckenbowra River Estuary, 7.5 km W of Batemans Bay, 35°42′S, 150°06′E, 5 m, on *Casuarina glauca*, *J. A. Elix 21864*, 4.viii.1988 (ANUC).

P. confusa resembles *P. truncata* Krempelh. and gives the same KC+ violet reaction due to the presence of picrolichenic acid but the two species are readily distinguished by the number and size of spores (8/ascus, 19-27 µm long, 12-15 µm wide in *P. truncata*) and the presence of lichexanthone in *P. confusa* (absent from *P. truncata*). The new species occurs in eastern Australia where it grows predominantly on mangroves.

P. epacrospora Archer sp. nov.

Thallus flavovirescens, tenuis, areolatus et rimosus, superficies subtuberculata et hebetata, isidiis et sorediis destitutus; corticola; apothecia verruciformia, conspicua, numerosa, conferta, saepe confluentia, thallo concoloria, plano-hemisphaerica, 0.4-0.8 mm diam.; ostiola

inconspicua, nigra margine translucide, in verrucis singula; sporae 2nae, fusiformes, laeves, 125-150(-180) µm longae, 35-45 µm latae.
Thallus acida thiophaninicum, sticticum et hyposticticum continens.

Type: Australia, New South Wales, Park Beach, Coffs Harbour, sea-level, on trees in coastal sand dune, *J. A. Elix 3427b*, 29.vi.1977; ANUC-holotype.

Thallus pale yellow-green, thin, areolate and cracked, surface slightly tuberculate and dull, lacking isidia and soredia, corticolous; *apothecia* verruciform, conspicuous, numerous, crowded, sometimes confluent, concolorous with the thallus, flattened hemispherical, 0.4-0.8 mm diam.; ostioles inconspicuous with a translucent margin, 1/verruca; *spores* 2/ascus, fusiform, smooth, 125-150(-180) µm long, 35-45 µm wide.
Chemistry: K-, KC+ yellow-orange, C+ yellow-orange, Pd-; thiophaninic, stictic and hypostictic acids.

The new species resembles the common Australian *P. thiospoda* Knight but is distinguished from that species by the larger fusiform spores (ellipsoid in *P. thiospoda*) and the presence of hypostictic acid (absent from *P. thiospoda*). *P. epacrospora* is known only from the type specimen.

Pertusaria errinundrensis Archer sp. nov.   Figure 3

Thallus stramineus, tenuis, granulosus vel tuberculatus, superficies hebetata, isidiis et sorediis destitutus, corticola; apothecia verruciformia, inconspicua, thallo concoloria, irregulariter hemisphaerica, basibus non constrictis, 0.7-1.4 mm diam., ostiola rara, inconspicua, nigra, punctiformia, in verrucis singula; sporae 8nae, biseriatae, ellipsoideae vel subfusiformes, laeves, 70-95 µm longae, 28-37 µm latae.
Thallus acidum protocetraricum continens.

Type: Australia, Victoria, Errinundra Flora Reserve, Goonmirk Rocks Road, 13 km S of Bendoc, 37°16′S, 148°53′E, 1200 m, on *Acacia* in *Eucalyptus* dominated forest, *H. Streimann 36621*, 10.iv.1986; CBG-holotype; B-isotype.

Thallus dull pale yellow, thin, granular to tuberculate, surface dull, lacking isidia and soredia, corticolous; *apothecia* verruciform, inconspicuous, irregularly hemispherical, concolorous with the thallus, not constricted at the base, 0.7-1.4 mm diam., ostioles uncommon, inconspicuous, black, punctiform, 1/verruca; *spores* 8/ascus, biseriate, smooth, ellipsoid to subfusiform, 70-95 µm long, 28-37 µm wide.
Chemistry: K-, KC-, C-, Pd+ orange-red; protocetraric acid.

P. errinundrensis is distinguished from other eight-spored corticolous Australian *Pertusaria* by asci with biseriate spores and the presence of protocetraric acid; it is known only from the type specimen.

Pertusaria hermaka Archer sp. nov. Figure 4

Thallus cinereo-olivaceus, rugosus et rimosus, superficies hebetata, isidiis et sorediis destitutus, corticola; apothecia verruciformia, conspicua, numerosa, thallo concoloria, hemisphaerica, basi constricta, interdum confluentia, 0.7-1.5 mm diam.; ostiola inconspicua, hyalina vel verrucis concoloria, raro fuscata, plana vel subpapilliformia, in verrucis 1-4na; sporae 4nae, uniseriatae, elongato-ellipsoideae, laeves, 90-120(-150) µm longae, 24-40 µm latae.
Thallus acidum 2′-O-methylperlatolicicum (raro solitarium) et 4,5-dichlorolichexanthone et raro acidum sticticum continens.

Type: Australia, Queensland, 3 km S of Forrest Beach, 16 km S of Ingham, 18°43′S, 146°18′E, edge of strand vegetation, 1 m, *J. A. Elix 15939*, 22.vi.1984; ANUC-holotype; *J. A. Elix 15882, 15900, 15915*, ANUC-topotypes.

Thallus pale greyish green, wrinkled and folded, cracked, surface dull, lacking isidia and soredia, corticolous; *apothecia* verruciform, conspicuous, numerous, concolorous with the thallus, hemispherical becoming constricted at the base, sometimes confluent, 0.7-1.5 mm diam.; ostioles inconspicuous, hyaline or concolorous with the thallus, rarely dark, flat or somewhat papilliform, 1-4/verruca; *spores* 4/ascus, uniseriate, elongate-ellipsoid, smooth, 90-125(-150) µm long, 25-40 µm wide.

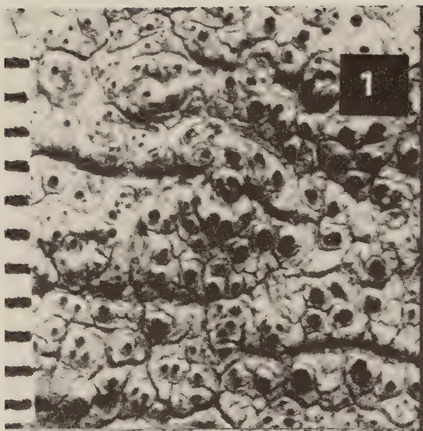
Chemistry: K-, KC-, C-, Pd-; 2′-O-methylperlatolic acid, usually with 4,5-dichlorolichexanthone and rarely with stictic acid.

Specimens examined.
QUEENSLAND. Coochiemudlo Island, Moreton, sea-level, in coastal scrub, *J. A. Elix 10445*, 5.ix.1982 (ANUC); Newell Beach, 5 km NE of Mossman, 1 m, on mangroves, *J. A. Elix 17453*, 6.vii.1984 (ANUC); Proserpine River valley, 20 km WNW of Proserpine, 150 m, *J. A. Elix 21100*, 2.vii.1986 (ANUC); Black Mountain, 25 km NW of Kuranda, 500 m, on *Acacia*, *J. A. Elix 17542*, 17.vii.1984 (ANUC); Bunya Mtns., Mt. Mowbullan, 950 m, *K. Kalb 20281*, 15.viii.1988 (herb.-KALB); Kuranda Range, NW of Cairns, 250 m, tropical rain forest, *K. Kalb 19811, 19814, 19821, 21606, 21611*, 23.viii.1988 (herb. KALB); W of Palm Cove, ca, 25 km N of Cairns, 100 m, dry Eucalypt forest, *K. Kalb 19951, 19882*, 26.viii.1988 (herb. KALB); Machans Beach, N of Cairns, 3 m, on mangroves in Barron River, *K. Kalb 21164, 21165*, 26.viii.1988 (herb. KALB).

The chemistry of *P. hermaka* is variable; 2′-O-methylperlatolic acid is usually present and may be the sole lichen compound as in Kalb 19951 and 20281, or more often it may occur with 4,5-dichlorolichexanthone e.g. as in Elix 17543 and Kalb 19814. Stictic acid is rarely the sole lichen compound as in Kalb 21606 and Elix 10445. *P. hermaka* occurs from sea-level to 950 m between latitudes 26° to 16° South in eastern Queensland where it grows in a variety of habitats such as coastal scrub, mangroves tropical rain forest and dry eucalypt forest. The majority of the specimens were collected near Cairns, Queensland, and are named from the Greek hermax, hermakos, a heap of stones, cf. Gaelic cairn, a heap of stones.

Pertusaria isidiosa Archer sp. nov. Figure 5

Thallus eburneus, tenuis, superficies hebetata, sorediis destitutus, isidiatus, corticola; isidia initio simplicia demum coralliformia, 0.4 mm longa, 0.05 mm diam., dispersa vel profusa; apothecia verruciformia, thallo concoloria, hemisphaerica, basibus constrictis, 0.8-1.5 mm diam., isidiata; ostiola non visa; sporae 2nae, uniseriatae, laeves, fusiformes, 100-112 µm longae, 30-35 µm latae. Thallus lichexanthone et acida 2′-O-methylperlatolicum et



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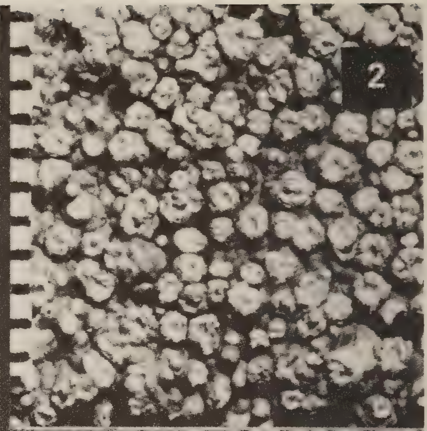

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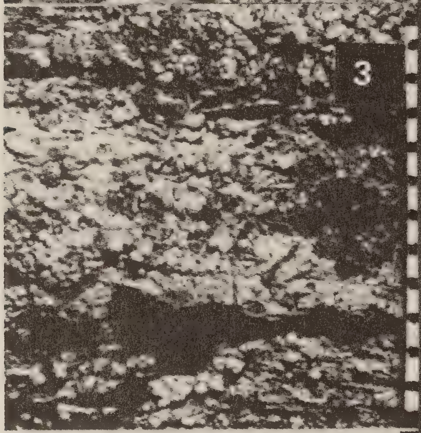

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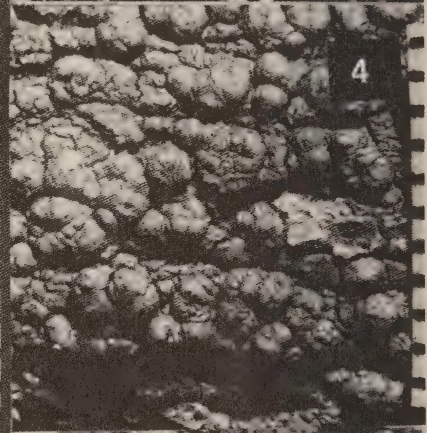

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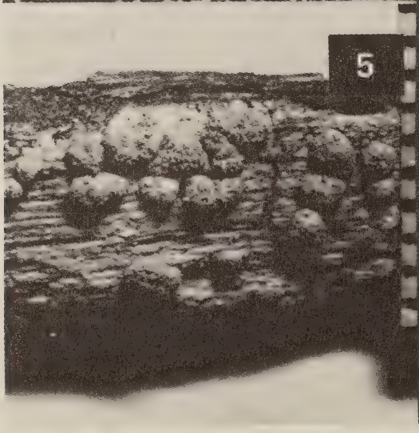

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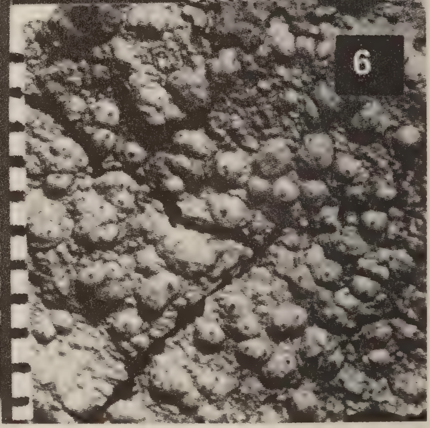


6

sticticum continens.

Type. Australia, Queensland, Weyba Creek, SW of Noosa Heads, ca. 70 km SE of Gympie, 26°24′S, 153°05′E, sea-level, on mangroves, *J. Hafellner 17951*, 27.vii.1986; GZU-holotype.

Thallus yellowish-white, thin, surface dull, lacking soredia, isidiate, corticolous; isidia initially simple, becoming coralloid, to 0.4 mm long, 0.05 mm diam., scattered to profuse; *apothecia* verruciform, hemispherical, constricted at the base, shortly isidiate, 0.8-1.5 mm diam., sometimes confluent; *spores* 2/ascus, uniseriate, fusiform, smooth, 100-112 µm long, 30-35 µm wide.
Chemistry. K-, KC-, C-, Pd-; lichexanthone, 2′-O-methylperlatolic and stictic acids.

Specimens examined.
QUEENSLAND. North Stradbroke Island, NE of Browns Lake, *J. Hafellner 19214, 19240,* 10.viii.1986 (GZU); Tandora *ca.* 25 km ENE of Maryborough, sea-level, on mangrove, *J. Hafellner 18214,* 23.viii.1986 (GZU).

P. isidiosa is distinguished from the isidiate *P. pseudodactylina* (q.v.) by the absence of salazinic acid, present in the latter species. The chemistry of the new species is variable; although the specimens listed above are all isidiate, only the type specimen possessed verrucae and contained the three compounds noted, i.e. a xanthone, an orcinol *p*-depside and a beta-orcinol depsidone. Of the remaining sterile specimens, Hafellner 19214 lacked stictic acid and Hafellner 19240 lacked lichexanthone. A second isidiate species, *P. subisidiosa* (q.v.), occurs in the same area but has four rough spores per ascus and contains stictic acid and 4,5-dichlorolichexanthone.

Pertusaria lacericans Archer sp. nov.

Sicut *Pertusaria lacerans* Müll.Arg. sed acidum

Figures 1-6. New species of *Pertusaria*. 1, *P. atropunctata*; 2, *P. confusa*; 3, *P. errinundrensis*; 4, *P. hermaka*; 5, *P. isidiosa*; 6, *P. paragibberosa.* Scale in mm.

protocetraricum continens vice acidum picrolichenicum.

Type. Australia. New South Wales, Cattle Creek State Forest, Briggsvale, 12 km NNE of Dorrigo, 30°15´S, 152°03´E, 700 m, on *Banksia integrifolia*, *D. Verdon 3843*, 13.x.1978; CBG 7809324-holotype.

Thallus olive-green, somewhat areolate and cracked, surface smooth and shiny, lacking isidia and soredia, becoming pustulate, the pustules opening at the top to reveal the white underlying medulla, 0.2-1 mm diam.; corticolous; *apothecia* disciform, inconspicuous, immersed in larger pustules; asci elongate-clavate, *ca*. 200 µm long and 50 µm wide; *spores* rare, one per ascus, elongate ellipsoid, smooth, thin-walled, 170-180 µm long, 35-40 µm wide, spore wall *ca*. 1 µm thick.
Chemistry: K-, KC-, C-, Pd+ orange; protocetraric acid.

Specimens examined.
QUEENSLAND. Bunya Mtns., ca. 56 Km NE of Dalby, 26°53´S, 151°37´E, ca. 1050 m, *J. Hafellner 16744, 18928*, 3.ix.1986 (GZU).
NEW SOUTH WALES. Mt. Boss State Forest, near Mt. Banda Banda, 44 km NW of Wauchope, 31°15´S, 152°20´E, 1200 m, on *Leptospermum*, *D. Verdon 4049*, 20.x.1978 (CBG 7809533); Styx River State Forest, ca. 85 km E of Armidale, 30°34´S, 152°20´E, 850 m, in warm-temperate rain forest *K. Kalb 21679*, 11.viii.1988 (herb. KALB).

The new species resmbles *P. lacerans* Müll.Arg. (Müller 1884) and is differentiated from that species by the presence of protocetraric acid in place of picrolichenic acid. *P. lacericans, P. lacerans* (*q.v.*) and *P. sublacerans* (*q.v.*) are three closely related and morphologically similar species in the subgenus *Pionospora* that differ chemically. All three taxa are rarely fertile. Müller reported *P. lacerans* to have single spored asci with large elongate spores but mature spores were not seen (Müller *loc. cit.*). A few fertile asci were seen in both *P. sublacerans* and *P. lacericans*. There are differences in distribution between the three species; *P. lacerans* and *P. lacericans* occur in eastern Queensland, the former between latitudes 17° and 20°S and the latter between latitudes 27° and 31°S. *P. sublacerans* occurs on Lord Howe Island, latitude 31°S. *P. lacericans* is known from the five specimens cited above and was reported to be "locally common" at the type location.

Pertusaria miscella Archer sp. nov.

Thallus albidus vel albido-cineraceus, tenuis, surrugosus et surrimosus, superficies laevis et nitida, isidiis et sorediis destitutus; corticola; apothecia disciformia, conspicua, disci in tumores plano-hemisphaericos vel irregularem, thallo concolores, 1-3 mm latos; disci albidi, plani vel concavi, epruinosi, 0.3-0.5 mm diam., margines involutis; sporae singulae, ellipsoideae, laeves, 100-112(-130) µm longae, 30-40(-50) µm latae, parietibus *ca.* 1 µm crassis.
Thallus lichexanthone et acidum thamnolicum continens.

Type. Australia, Queensland, Clarke Range, 46 km S of Proserpine, 20°50′S, 148°32′E, 800 m, on dead log in *Eucalyptus/Casuarina* dominated woodland, *J. A. Elix 20942*, 29.vi.1986; ANUC-holotype.

Thallus off-white to very pale grey, thin, slightly wrinkled and cracked, surface smooth and shiny, lacking isidia and soredia, corticolous; *apothecia* disciform, conspicuous, scattered, the discs clustered on flattened verrucae-like swellings sub-hemispherical or irregular in outline, concolorous with the thallus, 1-3 mm wide; discs white, flat or concave, sunken, 0.3-0.5 mm diam., surface epruinose, margins inrolled; *spores* 1/ascus, ellipsoid, smooth, 100-130 µm long, 30-40(-50) µm wide, spore wall *ca.* 1 µm thick.
Chemistry. K+ yellow, KC-, C-, Pd+ yellow; lichexanthone and thamnolic acid.

With disciform apothecia on verrucae-like swellings, *P. miscella* displays a mixture of structures from the sub-genera *Pionospora* and *Pertusaria* (Dibben 1980) but the thin-walled spores place the new species in the sub-genus *Pionospora*. *P. miscella* is differentiated from other Australian *Pertusaria* in the subgenus *Pionospora* by the morphology of the apothecia. *P. miscella* is known only from the type specimen.

Pertusaria norstictica Archer sp. nov.

Thallus albidus vel pallido-olivaceus, areolatus et rimosus, superficies hebetata, isidiis et sorediis destitutus; corticola; apothecia verruciformia, numerosa, dispersa, raro confluentia, plano-hemisphaerica, thallo concoloria, 1-2 mm diam.; ostiola nigra, punctiformia, inconspicua, in zona hyalina 0.2-0.3 mm diam., in verrucis 1-3na; sporae 8nae, uniseriatae, elongato-ellipsoideae vel subfusiformes, laeves, 60-95 µm longae, 20-37 µm latae. Thallus acidum norsticticum continens.

Type. Australia, Tasmania, Campania, 27 km N of Hobart, on *Acacia mearnsii*, in open woodland, *G. Kantvilas 211/81*, 22.iii.1981; HO 122809-holotype.

Thallus off-white to pale olive-green, areolate and cracked, surface dull, lacking isidia and soredia, corticolous; *apothecia* verruciform, numerous, scattered, rarely confluent, flattened hemispherical, concolorous with the thallus, 1-2 mm diam.; ostioles black, punctiform, inconspicuous, in a hyaline zone 0.2-0.3 mm diam., 1-3/verruca; *spores* 8/ascus, uniseriate, elongate-ellipsoid to subfusiform, smooth, 60-95 µm long, 20-37 µm wide.
Chemistry. K+ red, KC-, C-, Pd+ yellow; norstictic acid with traces of stictic acid and rarely with atranorin.

Specimens examined.
QUEENSLAND. Tandora, 25 km ENE of Maryborough, sea-level, *J. Hafellner 18255*, 23.viii.1986 (GZU); Bunya Mtns., ca. 56 km NE of Dalby, 1050 m, *J. Hafellner 18935*, 3.ix.1986 (GZU); Bunya Mtns., on road to Maidenwell, 1.8 km NE of the intersection, 920 m, *J. Hafellner 19672* (GZU).
NEW SOUTH WALES. Minyon Falls, 25 km NE of Lismore, *D. Verdon 3935* 17.x.1982 (CBG 7809416); Mt. Wilson, Blue Mountains National Park, 1000 m, *K. Kalb 20467*, 31.vii.1988 (herb. KALB).

P. norstictica can be distinguished from other Australian *Pertusaria* species with norstictic acid such as *P. undulata* Mull.Arg. (by the uniseriate spores and the absence of 4,5-dichloro-lichexanthone) and an un-named species from Norfolk Island (by the larger spores), and from the Hawaian *P. rubroreagens* H. Magn. (Magnusson & Zahlbruckner 1944) by the number of spores, four in the Hawaian species. The Queensland specimen *Hafellner 18255* contained atranorin in addition to norstictic acid.

Pertusaria paragibberosa Archer sp. nov. Figure 6

Thallus pallido-olivaceus, rugosus et surrimosus, superficies, hebetata, isidiis et sorediis destitutus ;corticola; apothecia verruciformia, thallo concoloria, numerosa, conspicua, saepe confluentia, hemisphaerica vel plano-hemisphaerica, basibus non constrictis, 0.5-1.5 mm diam.; ostiola inconspicua, fusca, punctiformia, in verrucas 2na; sporae 8nae, irregulariter uniseriatae vel sub-biseriatae, laeves, elongato-ellipsoideae vel subfusiformes, 75-100(-117) µm longis, 30-40 µm latis. Thallus 4,5-dichlorolichexanthone et acidum 2′-O-methylperlatolicum continens.

Type. Australia, New South Wales, Nonbah property, ca. 4 km W of Hume Highway, 20 km N of Holbrook, *R. Filson 15364*, 31.v.1975; MEL 1035862-holotype.

Thallus pale olive-green, wrinkled, somewhat cracked, surface dull, lacking isidia and soredia; corticolous; apothecia verruciform, concolorous with the thallus, conspicuous, scattered or sometimes confluent, hemispherical to flattened hemispherical, not constricted at the base, 0.5-1.5 mm diam,; ostioles inconspicuous, dark brown, punctiform, somewhat mammiform, 1-2/verruca; spores 8/ascus, irregularly uniseriate or biseriate, smooth, elongato-ellipsoid to subfusiform, 75-100(-117) µm long, 30-40 µm wide.
Chemistry: K-, KC-, C-, Pd-; 4,5-dichlorolichexanthone and 2′-O-methylperlatolic acid

Specimens examined.
QUEENSLAND. Four Mile Beach, 1 km S of Port Douglas, 16°29′S, 145°38′E, *D. Verdon 5443*, 6.ii.1983 (CBG 8301788); Bunya Mtns., Mt. Mowbullan, 1000m, *K. Kalb 21482*, 15.viii.1988 (herb. KALB).
NEW SOUTH WALES. Chaelundi Mtn., 37 km N of Ebor, 1376 m, on *Dysoxylum*, *D. Verdon 3896*, 14.x.1978 (CBG 7809376, H); Springwood, Blue Mtns., Glenbrook Creek, Sassafras Gully, *K. Kalb 20501*, 29.vii.1988 (herb. KALB).

P. paragibberosa resembles the common and widely distributed Australian species *P. gibberosa* Müll.Arg. but is distinguished from that species by the size of the spores and the shape of the verrucae. The spores in *P. gibberosa* never become fusiform and rarely exceed 70 µm in length and 30 µm in width. In contrast to the wide distribution of *P. gibberosa*, which occurs in all States and is particularly common in New South Wales and Victoria (Archer 1991), the new species is known only from New South Wales and Queensland.

Pertusaria patellifera Archer sp. nov. Figure 7

Thallus subolivaceus, rugosus et rimosus, sorediis et isidiis destitutus; corticola; apothecia disciformia, conspicue patelliformia, interdum in 2-3 patellae parviores dividentes, numerosa et dispersa, 1-3 mm diam., disci concavi, albipruinosi; asci clavati, raro fertiles; sporae singulae, late ellipsoideae, laeves, 150-170 µm longis, 45-55 µm latis, parietibus *ca.* 1 µm crassis. Thallus atranorin et acidum picrolichenicum continens.

Type: Australia, Queensland, 8 km E of Mt. Mowbullan, Bunya Mtns., 600 m, on roadside shrub, *R. Rogers 8975*, 15.viii.1985; BRIU-holotype.

Thallus pale olive-green, wrinkled and cracked, lacking isidia and soredia, corticolous; *apothecia* disciform, conspicuously dish-shaped, sometimes dividing into 2-3 smaller dishes, numerous and scattered, concolorous with the thallus, 1-3 mm diam., discs concave, white pruinose; asci clavate, rarely fertile; *spores* 1/ascus, broadly ellipsoid, smooth, thin-walled, 150-170 µm long, 45-55 µm wide.
Chemistry: K-, KC+ violet, C-, Pd-; atranorin, picrolichenic acid and picrolichenic acid homologues, Rf(C) 56, 49 and 33.

P. patellifera is characterised by the conspicuous dish-like apothecia, the single spored asci and the presence of atranorin and picrolichenic acid. The new species resembles species of *Thelotrema* but is distinguished from species in that genus by the simple spores (spores are septate or muriform in *Thelotrema*) and from other Australian picrolichenic acid containing *Pertusaria* by the conspicuous dish-like apothecia (see Figure 7). The thin-walled spores place the new species in the subgenus *Pionospora*. *P. patellifera* is known only from the type specimen.

Pertusaria pseudodactylina Archer sp. nov.

Thallus cineraceus, surrimosus, superficies laevis et nitida, sorediis destitutus, isidiata; saxicola; isidia numerosa, conferta, thallo concoloria, simplicia, 1-2 mm alta, 0.3-0.5 mm diam; apothecia ignota.
Thallus acidum salazinicum continens.

Type: Australia, Tasmania, Mt. Cameron, 390 m, on granite, *G. C. Bratt 73/1240*, 25.xi.1973; HO 31989-holotype.

Thallus greyish white, slightly cracked, surface smooth and shiny, lacking soredia, densely isidiate, saxicolous; *isidia* crowded, concolorous with the thallus, simple, unbranched, 1-2 mm tall, 0.3-0.5 mm diam.; *apothecia* not seen.
Chemistry: K+ yellow becoming red, KC-, C-; Pd+ orange; salazinic acid with traces of consalazinic acid.

The new species resembles the bipolar *P. dactylina* (Ach.) Nyl. but the thallus and isidia are darker and no asci or spores were seen. The two species also differ chemically; *P. dactylina* contains fumarprotocetraric acid (Dibben 1980:52) and the new species, salazinic acid. *P. pseudodactylina* is known only from the type specimen from Tasmania.

Pertusaria remota Archer sp. nov.

Thallus subflavidus vel griseo-flavidus, tenuis, diffusus vel discontinuus, areolatus et rimosus, superficies laeves et hebetata, isidiis destitutus, sorediatus; saxicola; soralia thallo concoloria, numerosa vel sparsa, disciformia vel hemisphaerica, 0.2-0.6 mm diam.; apothecia non visa.
Thallus acida thiophaninicum, hyposticticum et sticticum continens.

Type: Australia, Western Australia, King Leopold Range, March Fly Glen, 64 km NE of Lennard River Crossing, along Gibb River Rd., 17°10´S 125°18´E, 350 m, on sheltered rock, *J. A. Elix 22221*, 14.v.1988; ANUC-holotype; *J. A. Elix 22219, 22225*, 14.v.1988; ANUC-topotypes.

Thallus thin to diffuse, discontinuous, dull yellow to dull greyish yellow, areolate and cracked, surface smooth and dull, lacking isidia, sorediate, saxicolous; *soralia* sparse, scattered or numerous, 0.2-0.6 mm diam., disc-like to hemispherical; *apothecia* not seen.
Chemistry: K-. KC-, C-, Pd-; thiophaninic, hypostictic and stictic acids with traces of lichexanthone and cryptostictic acid.

Specimens examined.
WESTERN AUSTRALIA. Kunnanurra, Observation Point NE of town, *A. C. Beauglehole 13904*, 29.vii.1965 (MEL 1028838); King Leopold Range, Inglis Gap, 46 km NE of Lennard River Crossing, along Gibb River Rd., 400 m, *J. A. Elix 22192*, 13.v.1988 (ANUC); ibid., gorge 3 km NW of Silent Grove, 63 km NE of the Lennard River Crossing, 350 m, *J. A. Elix 22237, 22245*, 16.v.1988 (ANUC); road to Mt. Joseph Yard, 25 km E of Lennard River Crossing, along Gibb River Rd., 100 m, *J. A. Elix 22283, 22293*, 17.v.1988 (ANUC); Duncan Highway, near Old Halls Creek, 14 km ESE of Halls Creek, 18°16´S 127°48´E, 340 m, *J. A. Elix 22376*, 19.v.1988 (ANUC);Lake Argyll Rd., 35 km SE of Kunnanurra, 16°01´S 128°59´E, 140 m, *J. A. Elix 22478, 22487*, 22.v.1988 (ANUC); ibid., *H. Streimann 39846*, 22.v.1988 (CBG 8804854).
NORTHERN TERRITORY. Kakadu National Park, Koonpara Gap, on sandstone, *M. F. Day s.n.*, 21.vii.1981 (ANUC); escarpment 2 km N of Victoria River Crossing, between Timber Creek and Katherine, 15°36´S 131°06´E, 200 m, *J. A. Elix 22497*, 23.v.1988 (ANUC); Umbrawarra Gorge, 22 km SW of Pine Creek, 13°59´S 131°41´E, 220 m, *J. A. Elix 22525*, 23.v.1988 (ANUC).

P. remota morphologically resembles the bright yellow saxicolous *P. persulphurata* Müll.Arg., common in the coastal region of eastern Australia (Archer 1991) but is distinguished from that species by the dull appearance and the presence of hypostictic acid as a major lichen acid; hypostictic acid is not present in *P. persulphurata*. *P. remota* occurs in northern Australia.

Pertusaria scaberula Archer sp.nov.

Thallus cinereus vel cinereo-albidus, tenuis; corticola; soralia numerosa, conspicuis, albidis, complanatis et disciformis; apothecia non visa.
Thallus lichexanthone et acidum thamnolicum continens.

Type: Australia, New South Wales. Springwood, Sassafras Creek, 65 km W of Sydney, 33°43′S, 150°34′E, 250 m, *A. Archer P 8,* 16.vii.1988; NSW-holotype.

Thallus off-white to greyish white, thin, areolate and cracked, surface smooth, sorediate, lacking isidia, corticolous; *soralia* white, conspicuous, becoming numerous away from the margin, flattened and disciform, 0.5-1.5 mm wide; *apothecia* not seen.
Chemistry: K+ weak yellow, or rarely red; KC−; Pd+ yellow; lichexanthone and thamnolic acid; rarely with additional norstictic acid.

Specimens examined.
QUEENSLAND. Noosa, Weybar Creek, *G. N. Stevens 2375,* -.xii.1975 (BRIU); Cribb Island, Serpentine Creek, *G. N. Stevens 1075,* -.ix.1975 (BRIU).
NEW SOUTH WALES. Patonga, on *Casuarina, G. N. Stevens s.n.,* 19.i.1978 (BRIU); McPherson Range, Gradys Creek, E of Cougal, 28°22′S, 153°00′E, 800 m, *J. Hafellner 19347,* 29.viii.1986 (GZU).
AUSTRALIAN CAPITAL TERRITORY. Gudgenby Gorge, 27 km S of Canberra, 35°37′S, 149°05′E, 700 m, *H. T. Lumbsch 5628f,* 9.ix.1987 (herb. LUMBSCH).

P. paeminosa Archer was recently described as a sorediate saxicolous and corticolous *Pertusaria* species based on a saxicolous type specimen (Archer 1990). The saxicolous specimens are however identical to the South American *P. subventosa* Malme (vide infra). An examination of additional corticolous and saxicolous specimens of *P. "paeminosa"* has shown some differences between the two types of specimens and the corticolous specimens are now considered to be a separate species, here described as *P. scaberula* (from the Latin scaberulus, slightly rough to the touch, refering to the sorediate thallus). The saxicolous and corticolous specimens differ chemically; *P. subventosa* contains picrolichenic acid, absent from the corticolous specimens, and may have the thamnolic acid, usually present, replaced by hypothamnolic acid whereas the corticolous specimens lack picrolichenic acid, do not have thamnolic acid replaced by hypothamnolic acid and may also contain norstictic acid. The two species also differ morphologically. The soralia in *P. scaberula* are disciform and do not become stipitate, in contrast to the soralia in *P. subventosa* which are subspherical, sometimes becoming stipitate and developing inconspicuous disciform apothecia. The new species somewhat resembles an unnamed disciform species with thamnolic acid but is distinguished from that species by the absence of disciform apothecia, and the presence of lichexanthone. Additional specimens (as corticolous *P. paeminosa*) are listed elsewhere (Archer 1990).

Pertusaria sordida Archer sp. nov.
Thallus albidus vel cineraceus, tenuis, granularis, superficies hebetata, sorediata, isidiis destitutus, margine albo; saxicola; soralia albida, numerosa, saepe aggregata, adnata, rotundata vel irregularia, 0.5-1.5 mm diam.; apothecia non visa.
Thallus atranorin et acidum fumarprotocetraricum continens.

Type. Australia, Queensland, Brandy Creek Road, 12 km NE of Proserpine, 20°21′S, 148°41′E, 120 m, on volcanic rocks in dry sclerophyll forest, *J. A. Elix 20816*, 28.vi.1986; ANUC-holotype.

Thallus off-white to pale grey (appearing dull brownish white due to the substrate), margin white, thin, granular, discontinuous, sorediate, lacking isidia, surface dull, saxicolous; *soralia* numerous, crowded, adnate, circular or irregular in outline, off-white, 0.5-1.5 mm diam.; *apothecia* and *spores* not seen.
Chemistry. K+ yellow, KC-, C-, Pd+ red; atranorin and fumarprotocetraric acid.

The new species resembles the saxicolous *P. subventosa* Malme (vide infra) but is dull in comparison to the white thallus and soralia of the latter species. The two species are readily differentiated by the colour reaction given with Pd; yellow with *P. subventosa* and red with *P. sordida*. The new species is known only from the type specimen.

Pertusaria subisidiosa Archer sp. nov. Figure 8

Thallus eburneus, tenuis, superficie laevi et non nitida, isidiata sed sorediis destitutus, corticola; isidia simplicissima, thallo concoloria, profusa, 0.1-0.3 mm longa, 0.05-0.1 mm diam.; apothecia verruciformia, thallo concoloria, inconspicua, dispersa, plano-hemisphaericalia, basibus non constrictis, 0.5-0.7 mm diam.; ostiola conspicua, nigra, in verrucis singula, 0.1-0.2 mm diam.; sporae 4nae, uniseriatae, ellipsoideae, parietibus interiis undulatis ("asper" sensu Dibben 1980), 82-95 µm longae, 30-35 µm latae.
Thallus acidum sticticum continens.

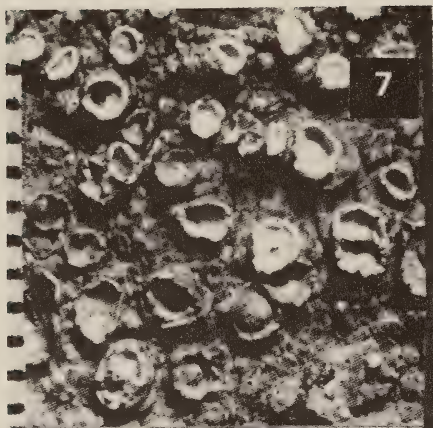
Type: Australia, Queensland, North Stradbroke Island, NE of Brown Lake, 27°29′S, 153°26′E, on fallen trunk in mixed forest, *J. Hafellner 19204*, 10.viii.1986; GZU-holotype.

Thallus pale cream-white, thin, continuous, surface smooth and dull, isidiate, lacking soredia, corticolous; *isidia* simple, concolorous with the thallus, profuse, 0.1-0.3 mm tall, 0.05-0.1 mm diam.; *apothecia* verruciform, concolorous with the thallus, inconspicuous, scattered, flattened hemispherical, not constricted at the base, 0.5-0.7 mm diam.; *ostioles* conspicuous, black, 0.1-0.2 mm diam., 1/verruca; *spores* 4/ascus, uniseriate, ellipsoid, rough, 82-95 µm long, 30-35 µm wide.
Chemistry: K-, KC-, C-, Pd-; stictic acid with traces of 4,5-dichlorolichexanthone.

The new species is distinguished from *P. isidiosa* by the number and morphology of the spores, and by the different chemistry. A chemically similar isidiate, un-named, Australian corticolous species, from Queensland and Norfolk Island, is distinguished from *P. subisidiosa* by the larger branched isidia, in contrast to the smaller, simple isidia in the new species. No apothecia have been seen in the un-named species. *P. subisidiosa* is known only from the type specimen.

Pertusaria sublacerans Archer sp. nov.

Sicut *Pertusaria lacerans* Müll.Arg. sed acidum norsticticum continens vice acidum picrolichenicum.



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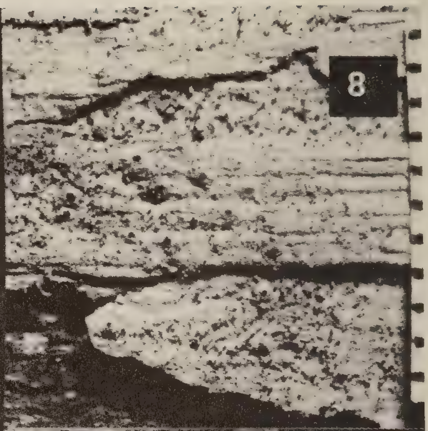

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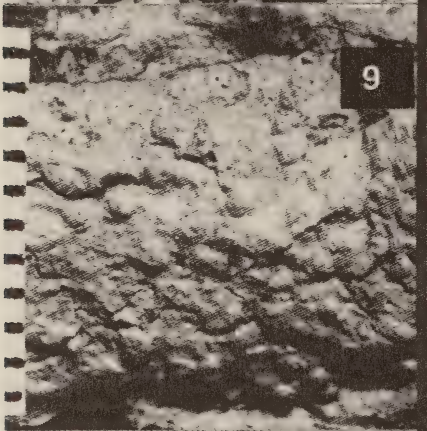

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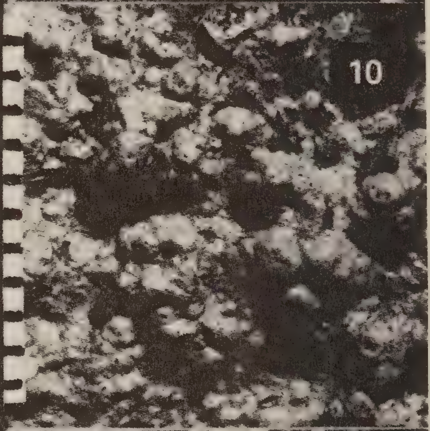

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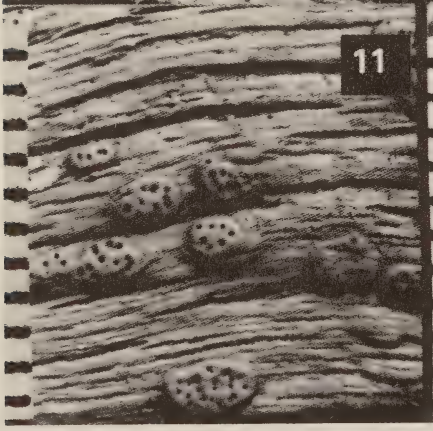

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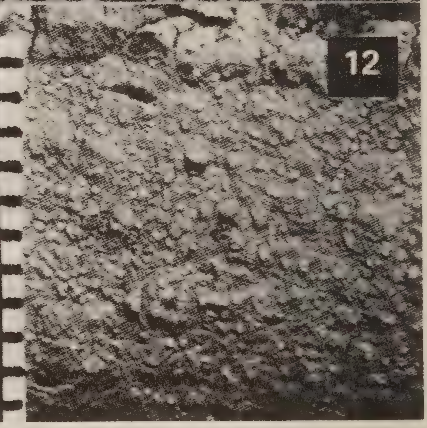

12

Type. Australia, New South Wales, Lord Howe Island, top of Intermediate Hill, 31°33′S, 159°06′E, on old banyan tree, ***W. W. Watts*** *s.n.*, -.vii.1911 (NSW L5219). NSW-holotype.

Thallus dull olive-green, thin, somewhat areolate and cracked, surface smooth and shiny, isidia and soredia absent, becoming pustulate, the pustules conspicuous, numerous, at first subisidioid, becoming hemispherical to subspherical, 0.5-1.5 mm diam., the upper part opening to reveal the white medulla; corticolous; *apothecia* discform, somewhat sunken, the disc white pruinose, 0.5-1 mm diam.; asci elongate-clavate, *ca.* 50 x 200 µm, *spores* rare, one per ascus, ellipsoid, smooth, 150-175 µm long, 60-70 µm wide, spore wall *ca.* 1 µm thick.
Chemistry: K+ red, KC-, C-, Pd+ yellow; norstictic acid with traces of stictic acid.

Specimens examined.
NEW SOUTH WALES, Lord Howe Island, Intermediate Hill, ***W. W. Watts*** *s.n.*, 10.vii.1911 (NSW L4557); Erskine Valley, ***W. W. Watts*** *s.n.*, 5.viii.1911 (NSW L4556).

The new species is morphologically identical to *P. lacerans* Müll.Arg (Müller 1884), described from Brazil, but has norstictic acid in place of picrolichenic acid. Both species are characterised by conspicuous pustules bursting to reveal the inner white medulla, or rarely white pruinose discs. *P. lacerans* also occurs in Australia (*vide infra*) but the two species are readily differentiated by their chemistry, which also distinguishes them from *P. lacericans* (*vide supra*).

Pertusaria subrhodotropa Archer sp. nov.

Thallus albidus vel pallido-griseus, tenuis, rugosus et rimosus, sorediis et isidiis destitutus; corticola; apothecia disciformia, thallo concoloria, dispersa, basibus constrictis, 0.5-1.5 mm diam., marginibus

Figures 7-12. New species of *Pertusaria*. 7, *P. patellifera*; 8, *P. subisidiosa*; 9, *P. thiophaninica*; 10, *P. trevethensis*; 11, *P. wilsonii*; 12, *P. xanthosorediata*. Scale in mm.

scabridis, involutis, postea dilatatis; disci mox expositi, rubro-brunei, initio spisse albipruinosi, plani vel concavi; asci clavati vel cylindrici; sporae 8nae, elipsoideae, irregulariter biseriatae, laeves, 50-65 µm longae, 20-32 µm latae, parietibus *ca*. 1 µm crassis. Thallus acidum lecanoricum continens.

Type. Australia, Western Australia, Beedalup Falls, W of Pemberton, 34°27′S, 116°01′E, *G. Bratt 67/451*, 15.x.1967; HO 51220-holotype.

Thallus off-white to pale grey, thin, wrinkled and cracked, lacking isidia and soredia, corticolous; *apothecia* disciform, concolorous with the thallus, scattered, constricted at the base, 0.5-1.5 mm diam., the margin scabrid, somewhat inrolled and obscuring the disc when immature; discs becoming exposed, pale red-brown, initially densely white pruinose, plane to concave; asci clavate to cylindrical; *spores* 8/ascus, irregularly biseriate, ellipsoid, smooth, 50-65 µm long, 20-32 µm wide, spore wall *ca*. 1 µm thick.
Chemistry. K-, KC+ orange-red, C+ orange-red, Pd-; lecanoric acid.

Specimen examined.
WESTERN AUSTRALIA. 48 km E of Merredin, 31°29′S, 118°17′E, 300 m, *G. Bratt 67/500*, 21.x.1967 (HO 51219).

The new species is named for its resemblance to *P. rhodotropa* Müll.Arg. described from Queensland; *P. rhodotropa* is a later name for *P. velata* (Turn.) Nyl. (Archer 1991) but *P. subrhodotropa* is distinguished from *P. velata* (which has one spore per ascus) by the eight spored asci. The new species is known only from the two localities in Western Australia.

Pertusaria thiophaninica Archer sp. nov. Figure 9

Thallus subviridi-flavus, tenuis, rimosus, isidiis et sorediis destitutus; corticola; apothecia verruciformia, numerosa, thallo concoloria, plano-hemisphaerica, saepe confluentia, basibus non constrictis, 0.5-1 mm diam.; ostiola conspicua, pallida vel atra, in zona hyalina vel sulphurea, in verrucis singula; sporae 8nae, irregulariter biseriatae, elongato-ellipsoideae, laeves, 75-95 µm longae,

30-40 µm latae.
Acidum thiophaninicum solum continens.

Type. Australia, South Australia, Ewans Ponds, on bark of *Cassinia, R. Filson 15806,* 8.iii.1977; MEL 1020691-holotype.

Thallus pale greenish-yellow, thin, cracked, lacking isidia and soredia, corticolous; *apothecia* verruciform, numerous, concolorous with the thallus, flattened hemispherical, often confluent, not constricted at the base, 0.5-1 mm diam.; ostioles conspicuous, pale to dark, 1/verruca in a colourless to pale yellow translucent zone; *spores* 8/ascus, irregularly biseriate, elongate-ellipsoid, smooth, 75-95 µm long, 30-40 µm wide.
Chemistry. K-, KC+ yellow-orange, C+ yellow-orange, Pd-; thiophaninic acid.

Specimens examined.
VICTORIA. Portland, Point Danger, growing on *Spyridium, R. Filson 7323,* 25.v.1965 (MEL 1023623).
QUEENSLAND. Bunya Mtns., Mt. Mowbullan, 26°53′S, 151°36′E, 1050 m, on *Acacia, K. Kalb 20402,* 14.viii.1988 (herb. KALB); *ibid.*, ca. 12 km NNE of Mt. Mowbullan, 680 m, *K. Kalb 21378,* 14.viii.1988 (herb. KALB).

P. thiophaninica is distinguished from the somewhat similar *P. meridionalis* var. *xanthostoma* Müll.Arg., which also occurs in Australia (Archer 1991), by the less conspicuous ostioles, the absence of stictic acid and the predominantly biseriate arrangement of the spores. *P. thiophaninica* also resembles the Carribean *Pertusaria flavens* Nyl. (Nylander 1869) in chemistry and spore number but the spores in *P. flavens* [holotype: Antilles francaises (Martinique), Camp Jacob, *Husnot 471,* 1868 (H-NYL 23632)] are smaller (52-65 µm long) than those of *P. thiophaninica. P. flavens* occurs in Brazil and Paraguay (Malme 1936) and South Africa (Doidge 1950) but has not been found in Australia.

Pertusaria thula Archer sp. nov.

Thallus flavus obscurus, tenuis, areolatus et rimosus, isidiis et sorediis destitutis; saxicola; apothecia

veruciformia, conspicua, thallo concoloria, plano-hemisphaerica, basi constrictis, interdum confluentia, 0.8-2 mm diam.; ostiola conspicua, verrucis concoloria, subpapilliformia, in verrucis 1-4na; sporae 8nae, irregulariter biseriatae, late ellipsoideae, laeves, 60-85 µm longae, 37-50 µm latae.
Thallus acidum thiophanicum continens.

Type. Australia, Queensland, The Tip or Top, Cape York Peninsula, 10°30´S 142°30´E, 150 m, *U. Allen s.n.*, 26.ix.1976; HO 50934-holotype.

Thallus dull yellow, thin, areolate and cracked, lacking isidia and soredia, surface dull, saxicolous; *apothecia* verruciform, conspicuous, concolorous with the thallus, flattened hemispherical, constricted at the base, sometimes confluent, 0.8-2 mm diam.; ostioles conspicuous, subpapilliform, concolorous with the verrucae, 1-4/verruca; *spores* 8/ascus, irregularly biseriate, broadly ellipsoid, smooth, 60-85 µm long, 37-50 µm wide.
Chemistry. K-, KC+ yellow-orange, C+ yellow-orange, Pd-; thiophanic acid.

The epithet "thula", from the Latin "Thule", farthest north, refers to the type locality which is the most northerly point in Australia. *P. thula* is known only from the type specimen collected from the tip of Cape York Peninsula. The collector´s note with the specimen reports "all rock covered profusely". The new species is distinguished from the somewhat similar *P. xanthoplaca* Müll.Arg. (which also occurs in Queensland) by the chemistry, the arrangement of the spores within the ascus and the number of ostioles. *P. xanthoplaca* contains lichexanthone and thiophaninic and stictic acids (Archer 1991), the spores are predominantly uniseriate and there is one inconspicuous ostiole per verruca.

Pertusaria trachyspora Archer sp. nov.

Thallus sub-olivaceus, rugosus et rimosus, superficies hebetata, sorediis et isidiis destitutus; corticola; apothecia verruciformia, conspicua, numerosa, thallo concoloria, hemisphaerica, 0.5-1 mm diam.; ostiola nigra, punctiformia, in verrucas 1-3na, in zona hyalina; sporae

2nae, uniseriatae, ellipsoideae, parietibus interioribus undulatus ("asper" sensu Dibben 1980), 95-120 µm longae, 30-37 µm latae.
Thallus 4,5-dichlorolichexanthone et acidum 2′-O-methylperlatolicum continens.

Type. Australia, Western Australia, Camp Creek, Mitchell Plateau, 14°53′S 125°45′E, on *Xanthostemon*, *R. J. Hnatiuk MP376*, 13.vi.1976; PERTH 003013-holotype.

Thallus pale olive-green, wrinkled and cracked, surface dull, lacking isidia and soredia, corticolous; *apothecia* verruciform, conspicuous, numerous, concolorous with the thallus, hemispherical, 0.5-1 mm diam.; ostioles black, punctiform, 1-3/verruca, in a hyaline zone; *spores* 2/ascus, uniseriate, ellipsoid, rough, 95-120 µm long, 30-37 µm wide.
Chemistry. K-, KC-, C-, Pd-; 4,5-dichlorolichexanthone and 2′-O-methylperlatolic acid.

The epithet "trachyspora", from the Greek "trachys, rough" refers to the appearance of the inner spore wall. *P. trachyspora* is known only from the type specimen.
P. trachyspora somewhat resembles *P. subtruncata* Müll.Arg. (Müller 1884) from Mauritius in that both taxa have two rough spores per ascus but the holotype of *P. subtruncata* [Mauritius, *Robillard s.n.*, 1876 (G)] contains 4,5-dichlorolichexanthone and stictic acid.

Pertusaria trevethensis Archer sp. nov. Figure 10

Thallus stramineus, surrimosus, margine bene definitus, superficies laevis et nitida, isidiis et sorediis destitutis; saxicola; apothecia verruciformia, thallo concoloria, conspicua, dispersa, raro confluentia, complanato-hemisphaerica, basibus non constrictis, 0.5-1 mm diam.; ostiola inconspicua, nigra, punctiformia, in verrucis 1-4na; sporae 4nae, uniseriatae, laeves, fusiformes, 85-105 µm longae, 28-35 µm latae.
Thallus 4,5-dichlorolichexanthone et acidum sticticum continens.

Type. Australia, Queensland, The Black Gap, Black Trevethen Range, 21 km SSW of Cooktown, 15°39′S 145°13′E, 300 m, on granite boulders, *J. A. Elix 17336*, 4.vii.1984;

ANUC-holotype.

Thallus dull yellow-brown, slightly cracked, surface smooth and shiny, margin well-defined, lacking isidia and soredia, saxicolous; *apothecia* verruciform, concolorous with the thallus, conspicuous, scattered, rarely confluent, flattened hemispherical, 0.5-1.0 mm diam.; ostioles inconspicuous, black, punctiform, 1-4/verruca; *spores* 4/ascus, uniseriate, smooth, fusiform, 85-105 µm long, 28-35 µm wide.
Chemistry. K-, KC-, C-, Pd-; 4,5-dichlorolichexanthone and stictic acid.

The new species resembles somewhat the more common saxicolous *P. lophocarpa* Körber (Archer 1991) but is distinguished from that species by the chemistry and the number of spores per ascus, which also differentiate *P. trevethensis* from *P. vulpina* (vide infra). *P. trevethensis* is known only from the type specimen.

Pertusaria vulpina Archer sp. nov.

Thallus albido-olivaceus, tenuis, rugosus et rimosus, superficies tuberculata et nitida, isidiis et sorediis destitutus; saxicola; apothecia verruciformia, thallo concoloria, inconspicua, plano-hemisphaerica, dispersa saepe confluentia, 2-3 mm diam.; ostiola conspicua, nigra, in verrucis 2-5na; sporae 2nae, elongato-ellipsoideae, laeves, (120-)150-175 µm longae, 40-55 µm latae. Thallus 4,5-dichlorolichexanthone et acidum sticticum continens.

Type: Australia, Queensland, Mt. Fox, 43 km SW of Ingham, 18°15′S 145°42′E, 780 m, on vesicular basalt, *J. A. Elix 20326*, 19.vi.1986; ANUC-holotype.

Thallus pale olive green, thin, wrinkled and cracked, surface tuberculate and shiny, lacking isidia and soredia, saxicolous; *apothecia* verruciform, inconspicuous, scattered, flattened hemispherical, constricted at the base, concave above, 0.7-1.5 mm diam., often becoming confluent, 2-3 mm diam.; ostioles conspicuous, black, 2-5/verruca or 10-15 on confluent verrucae; *spores* 2/ascus, elongate-ellipsoid, smooth, (120-)150-175 µm long, 40-55 µm wide.

Chemistry: K+ weak yellow, KC-, C-, Pd-; 4,5-dichlorolichexanthone and stictic acid.

The new species is distinguished from the chemically similar saxicolous *P. trevethensis* (*q.v.*) by the number, size and morphology of the spores. The epithet "vulpina" refers to Mount Fox, the type locality. *P. vulpina* is known only from the type specimen.

Pertusaria wilsonii Archer sp. nov. Figure 11

Thallus albidus vel cineraceus, rugosus et areolatus, isidiis et sorediis destitutus; corticola; apothecia verruciformia, conspicua, thallo concoloria, numerosa, interdum confluentia, plano-hemisphaerica, basibus constrictis, 1-2 mm diam.; ostiola conspicua, punctiformia, nigra, interdum depressa, in verrucis 3-8(-15)na; sporae 2 nae, uniseriatae, elongato-ellipsoideae, parietibus interioribus undulatus ("asper" sensu Dibben 1980), 110-160 µm longae, 35-50 µm latae.
Thallus acidum protocetraricum continens.

Type: Australia, Queensland, Clarke Range, 46 km S of Proserpine, 20°50´S, 148°32´E, 800 m, on dead log in *Eucalyptus-Casuarina* dominated woodland, *J. A. Elix 20943*, 29.vi.1986; ANUC-holotype.

Thallus off-white to pale grey, wrinkled, cracked and areolate, surface dull, lacking isidia and soredia, corticolous; *apothecia* verruciform, conspicuous, concolorous with the thallus, numerous, sometimes confluent, flattened hemispherical, constricted at the base, 1-2 mm diam.; ostioles conspicuous, black, punctiform, sometimes sunken, 3-8/verruca; *spores* 2/ascus, uniseriate, elongate-ellipsoid, rough , 110-160 µm long, 35-50 µm wide.
Chemistry. K-,KC-, C-, Pd+ orange-red; protocetraric acid.

Specimens examined.
QUEENSLAND. Killarney, South Queensland, *F. R. M. Wilson s.n.*, -.-.1890 (H); Ravenshoe State Forest, Cardwell Range, 41 km SE of Ravenshoe, 780 m, *J. A. Elix 16084*, 23.vi.1984 (ANUC); Track to Mt. Lewis, 19 km NNW of Mt. Malloy, 1200m, *J. A. Elix 16926*, 30.vi.1984 (ANUC);

D´Aguilar Range, NW of Brisbane, ca. 2 km N of Mt. Glorious, 700 m, *J. Hafellner 18112,* 1.viii.1986 (GZU); Gambubal State Forest, Bald Mountain, E of Emu Vale, 1100 m, *J. Hafellner 16336,* 7.ix.1986 (GZU).
NEW SOUTH WALES. Buckenbowra River Estuary, 7 km W of Batemans Bay, 1 m, *K. Kalb 18228, 18926,* 4.viii.1988 (herb. KALB); Cowan Creek, near Bobbin Head, ca. 25 km N of Sydney, on *Casuarina, A. Archer P 47,* 17.vi.1989, (NSW).
VICTORIA. Lakes Entrance, *F. Wilson s.n.*, -.iii.1889, (NSW L4443).

Pertusaria wilsonii var. **aphelospora** Archer var. nov.

Sicut *Pertusaria wilsonii* var. *wilsonii* sed sporis laevibus (sensu Dibben 1980).

Type. Australia, Queensland, Black Mountain, 25kKm NW of Kuranda, 16°40´S, 145°29´E, 500 m, on *Acacia, J. A. Elix 17507,* 7.vii.1984; ANUC-holotype.

Pertusaria wilsonii var. *aphelospora* is distinguished from var. *wilsonii* by the smooth spores; the remaining morphology and chemistry are identical with those of var. *wilsonii*.

Specimens examined.
QUEENSLAND. Ravenshoe State Forest, Tully Falls Road, 18 km SE of Ravenshoe, on *Schefflera, J. A. Elix 16156,* 23.vi.1984 (ANUC); Weyba Creek, 70 km SE of Gympie, sea-level, *J. Hafellner 17988,* 27.vii.1986 (GZU); Noosa River, NE of Tewantin, sea-level, *J. Hafellner 19211,* 27.vii.1986 (GZU); Tandora, ca. 25 km ENE of Maryborough, sea-level, *J. Hafellner 18309,* 23.viii.1986 (GZU).
NEW SOUTH WALES. N of Gloucester, 50 m, in rain forest, *K. Kalb 20354,* 9.viii.1988 (herb. KALB).
P. wilsonii is named after the Reverend F. R. M. Wilson, 1832-1903, who made extensive collections of Australian lichens and who collected the first specimens of the new species in 1889 and 1890.

P. wilsonii resembles *P. trypetheliiformis* Nyl., described from Tahiti, (Nylander 1859) but the holotype of that species (Tahiti, Lepine 17, H-NYL 23588) has 4 spores per ascus (30-45 x 70-85 µm) and contains stictic acid. The verrucae and ostioles of *P. wilsonii* also resemble those of *P. javanica* Müll.Arg. (Müller 1884) but the holotype of that species [Java, ?collector, 1882 (G)] has four rough spores per ascus (40-47 x 87-137 µm) and also contains stictic acid. Var. *aphelospora* occurs in Queensland and New South Wales to latitude 32° S whereas var. *wilsonii* also occurs further south in Victoria, to latitude 37° S.

Pertusaria xanthosorediata Archer sp. nov. Figure 12

Thallus albidus vel stramineus, surrimosus, superficies hebetata, isidiis destitutus, copiose sorediata; corticola; soredia aurea, erumpentia, rotundata, 0.2-0.4 mm diam.; apothecia verruciformia, thallo concoloria, pauca vel absentia, hemisphaerica, 0.5-0.8 mm diam.; ostiola inconspicua, thallo concoloria, in verrucis singula; sporae 8nae, biseriatae, fusiformae, laeves, 60-65 µm longae, 20-22 µm latae.
Thallus acidum thiophaninicum et acidum sticticum continens.

Type. Australia, Queensland, Perseverance Dam, SE of Crows Nest, 27°17′S, 152°07′E, 480 m, in eucalypt forest, *J. Hafellner 18663*, 4.ix.1986; GZU-holotype.

Thallus off-white to dull yellow, somewhat cracked, surface dull, lacking isidia, copiously sorediate, corticolous; soredia bright yellow, erumpent, irregularly rounded, 0.2-0.4 mm diam.; *apothecia* verruciform, concolorous with the thallus, few to absent, hemispherical, 0.5-0.8 mm diam.; ostioles inconspicuous, concolorous with the thallus, 1/verruca; *spores* 8/ascus, irregularly biseriate, fusiform, smooth, 60-65 µm long, 20-22 µm wide.
Chemistry. K-, KC+ orange, C+ weak orange, Pd-; thiophaninic and stictic acids.

Specimen examined.
QUEENSLAND. Noosa River, NE of Tewantin, 70 km SE of Gympie, 26°23′S, 153°02′E, sea-level, on mangrove, *J. Hafellner 19650*, 27.vii.1986 (GZU).

The new species is known from two specimens, only one of which is fertile. It is characterised by the distinctive bright yellow soralia and when fertile by the eight fusiform biseriate spores per ascus.

New records

Pertusaria commutata Müll.Arg., *Flora* 67: 269 (1884).

Type. Venezuela, Caracas, *Dr. Ernst s.n.*; G-lectotype (here selected); US-isolectotype.

Thallus pale grey, wrinkled, folded and cracked, not areolate, surface dull, lacking isidia and soredia, corticolous; *apothecia* disciform, numerous and crowded, adnate, 0.4-0.8 mm diam., surface of the discs coarsely white pruinose; asci clavate, sometimes curved, 125-150 µm long, 35-60 µm wide; *spores* one per ascus, uncommon, ellipsoid, smooth, 100-135 µm long, 35-50 µm wide, wall *ca.* 1 µm thick.
Chemistry: K+ yellow, KC-, C-, Pd+ yellow; lichexanthone and haemathamnolic acid.

Specimens examined.

AUSTRALIA, QUEENSLAND. North Stradbroke Island, on *Avicennia maritima, R. Rogers 1990,* 10.viii.1972 (BRIU); Bunya Mountains, 26°51′S, 151°34′E, *J. M. Gilbert s.n.,* 8.ix.1974 (HO 50945); Keppels Sands, Fitzroy Estuary, on *Excoecaria, R. Rogers 769,* 10.vi.1975 (BRIU); Noosa River, on *Avicennia, G. N. Stevens 2386,* 18.xii.1975 (BRIU); Noosa Sound, on *Rhizophora, G. N. Stevens 2371,* 31.xii.1975, (BRIU); Springbrook, ca. 110 km S of Brisbane, on *Callistemon, H. T. Lumbsch 5391f,* 11.viii.1987 (herb. LUMBSCH).

When Müller described *P. commutata* he made no reference to a holotype or to syntypes. A number of specimens labelled "*Pertusaria commutata*" from the Müller Herbarium (G) were examined to choose a lectotype; one of the specimens [Rio de Janerio; Glaziou 5067, 1875] was referrred to as the holotype of *P. ornatula* Müll.Arg. (Müller 1884) and was identical in appearance to that holotype, (*vide infra*) with the same number. Of the remaining six specimens labelled *P. commutata,* only one [Caracas: Dr. Ernst] is stamped "J. Müller Arg. det." and this is selected as lectotype. Dibben examined a duplicate of this specimen in

US and reported the presence of lichexanthone and haemathamnolic acid (Dibben 1980:52); these two compounds were also present in the specimen from Geneva. Müller did not report the dimensions of the spores in *P. commutata* but compared them to those of *P. velata* (Turn.) Nyl.; the range reported for this species (Dibben 1980:76) is 31-97 x 120-225 µm. In the Australian specimens listed above, the spore sizes were 35-50 x 100-135 µm. Vainio (1890:105) reported spore sizes of 26-42 x 90-114 µm for specimens from Brazil.

P. commutata was reported from Queensland (Shirley 1893) and Tasmania (Jatta 1910) but specimens corresponding to these reports have not been seen. Jatta (1910) also reported *P. aggregata* Müll.Arg. and *P. ornatula* Müll.Arg. (Müller 1884) from Tasmania but the presence of these three sub-tropical species in Tasmania (ca. 45°S) is unlikely and they may be misidentifications of *P. novaezelandiae* Szatala which is common and widespread in Tasmanian rainforests (Kantvilas 1990). *P. commutata* resembles the single-spored *P. aggregata* [lectotype here selected: Brazil, Apiahy, Puiggari 2676, 1883 (G)], which also contains haemathamnolic acid, but is distinguished from that species by the simple adnate apothecia in contrast to the slightly stipitate compound apothecia in *P. aggregata* and the absence of lichexanthone. When Müller described *P. aggregata*, he referred to two syntypes from Brazil, Puiggari 2676 and 2750. The specimen labelled "Puiggari 2676" is also labelled "L.B.n. 710", a reference to the publication "Lichenologische Beiträge species number 710" (Müller loc. cit.) and is therefore selected as lectotype. *P. commutata* is differentiated from the single-spored *P. ornatula* [holotype: Brazil, Rio de Janeiro, Glaziou 5067, 1878 (G)] (which also contains haemathamnolic acid) by the olive green thallus, the absence of lichexanthone and the sparse apothecia, in contrast to the numerous, crowded apothecia in *P. commutata*.

Pertusaria consanguinea Müll.Arg., *Flora* 67: 283 (1884)

Type. Brazil, Apiahy, *Puiggari s.n.*, -.-.1880; G-lectotype (here selected).

Thallus pale fawn, thin, scattered and dispersed on the substrate, surface smooth and dull, margin well-defined,

lacking isidia and soredia, saxicolous; *apothecia* verruciform, verrucae conspicuous, scattered, flattened hemispherical, sometimes confluent,1-2(-3) mm diam., usually constricted at the base; ostioles inconspicuous, black, punctiform, sometimes sunken, 1-2/verruca; *spores* 8/ascus, uniseriate, ellipsoid to subfusiform, smooth, 75-105 µm long, 35-50 µm wide.
Chemistry: K-, KC-, C-, Pd-; lichexanthone and 2-O-methylperlatolic acid.

Specimen examined.
Australia, New South Wales, Bundeena, Royal National Park, 4 m, on sandstone rocks, *J. A. Elix 2299*, 13.iv.1976 (ANUC).

The protologue to *P. consanguinea* refers to material collected in Brazil. The Müller Herbarium contains two specimens labelled *P. consanguinea* and collected by Puiggari in Brazil in 1880 and 1882 respectively. The specimen dated 1882 is very small and is labelled "L.B. n." with no number whereas the specimen dated 1880 is labelled "L.B. n. 717", a reference to the publication, viz. Lichenologische Beiträge, species number 717 (Müller 1884) and this specimen is therefore selected as the lectotype.
P. consanguinea closely resembles the saxicolous *P. lophocarpa* Körber, from south-eastern Australia and New Zealand [*P. superba* Zahlbr., nom. inval. (Archer 1991)] but is distinguished from that species by the presence of lichexanthone and 2-O-methylperlatolic acid in place of 2,4-dichlorolichexanthone and 2′-O-methylperlatolic acid in *P. lophocarpa*, and the inconspicuous ostioles (the ostioles are dark and conspicuous and often sunken in *P. lophocarpa*). *P. consanguinea* also resembles the saxicolous *P. rudis* Müll.Arg. (Müller 1884) [holotype: Brazil, Morro de Itambe, *Puiggari 2176*, -.iv.1882 (G)] which also contains eight spores per ascus and lichexanthone and 2-O-methylperlatolic acid but the spores in this species are smaller (75-85 µm long) than those of *P. consanguinea* and are ellipsoid, not becoming fusiform.

Pertusaria dehiscens Müll.Arg., *Flora* 67: 349 (1884)

Type: Brazil, Apiahy [Apiai, ca. 250 km SW of Sao Paulo], *Puiggari s.n.*, -.vii.1882; G-lectotype ("M. Oshio 1978").

Thallus pale to dark olive green, wrinkled and cracked, lacking isidia and soredia, surface dull, corticolous; *apothecia* verruciform, conspicuous, numerous, concolorous with the thallus, flattened hemispherical, 0.8-1.5 mm diam., often constricted at the base; ostioles black, punctiform, 2-5/verruca, in a hyaline zone, the zone becoming conspicuous, deeply concave and almost disciform, to 0.8 mm diam.; *spores* 8/ascus, biseriate, smooth, fusiform, 100-140(-150) µm long, 35-50 µm wide. *Chemistry:* K-, KC-, C-, Pd-; lichexanthone, stictic acid and traces of norstictic acid.

Specimens examined.
NORFOLK ISLAND. Mt. Pitt Reserve, King Fern Valley, 260 m, on palm, *J. A. Elix 18682,* 7.xii.1984 (ANUC); Mt. Pitt Reserve, S of summit of Mt. Pitt, 230 m, on *Citrus limonia, J. A. Elix 18809,* 10.xii.1984 (ANUC).
QUEENSLAND. Clarke Range, 46 km S of Proserpine, 800 m, on *Argyrodendron, J. A. Elix 20843,* 29.vi.1986 (ANUC).
NEW SOUTH WALES. Cockerawombeeba Creek, Mt. Boss State Forest, 700 m, on *Polysoma, D. Verdon 4074,* 21.x.1978 (CBG 7809562); Ballawongarah, 11 km SE of Kangaroo Valley, 455 m, *J. A. Elix 8951,* 17.ix.1980 (ANUC); 44 km E of Robertson, 730 m, *J. A. Elix 8903,* 17.ix.1980 (ANUC); Royal National Park, Bola Creek, E of Waterfall, 250 m, *K. Kalb 18898, 18900,* 2.viii.1988 (herb. KALB); Buladelah district, Myall River State Forest, E of Stroud, 150 m, *K. Kalb 17963,* 7.viii.1988 (herb. KALB); 6 km N of Glen Martin, S of Dungog, *H. Mayrhofer 8886,* 15.viii.1988 (GZU).

P. dehiscens is characterised by the 8 biseriate fusiform spores and the presence of lichexanthone and stictic acid; lichexanthone may rarely be absent as in *J. A. Elix 8903, vide supra*. The species resembles the endemic New Zealand *P. theochroa* Krempelh. but is distinguished from that species by the different chemistry; *P. theochroa* contains 4,5-dichlorolichexanhone and 2′-O-methylperlatolic acid. *P. dehiscens* resembles *P. phaeostoma* Müll.Arg. (Müller 1884) [holotype: Brazil, Apiahy, *Puiggari s.n.*, -.iii.1881 (G)] which also has 8 biseriate spores per ascus, 30-45 x 120-140 µm, and contains lichexanthone but in the latter species the spores are elongate-ellipsoid rather than fusiform as in *P. dehiscens* and the ostioles in *P. phaeostoma* are one per verruca, conspicuous, black, sunken and almost disc-like.

Pertusaria lacerans Müll.Arg., *Flora* 67: 270 (1884)

Type. Brazil, Apiahy, *Puiggari s.n.*, -.v.1881; G-holotype.

P. lacerans is morphologically similar to *P. lacericans* and *P. sublacerans* (vide supra).
Chemistry: K-, KC+ violet, C-, Pd-; picrolichenic acid with traces of lichexanthone and a picrolichenic acid homologue, Rf(C) 29.

Specimens examined.
QUEENSLAND. Atherton Scrub [near Atherton, *ca.* 17°20´S, 145°25´E], *R. Mitchell s.n.*, -.viii.1911 (NSW L5112); Clarke Range, 46 km SE of Proserpine, 20°50´S, 148°32´E, 600 m, on *Argyrodendron*, *J. A. Elix 20848*, 29.vi.1986 (ANUC).

P. lacerans was reported from Tasmania (Jatta 1910) but the specimen on which this report was based was not seen. A specimen from the Müller herbarium [Tasmania, *Rev. Wilson, s.n.*, 1893 (G)], labelled *P. lacerans*, contains hypothamnolic acid and is identified as *Pertusaria novaezelandiae* Szatala, a common and widespread species in Tasmanian rainforests (Kantvilas 1990).

Pertusaria leioplacella Nyl., *Bull. Soc. Normand.* (2)2: 71 (1868).

Type: New Caledonia, Lifu, *E. Marie s.n.*, 1863; lectotype-H-NYL 23640, ("Awasthi & Srivastava 1988").

A detailed description of *P. leioplacella* is given by Malme (Malme 1936).
Chemistry. K-, KC+ yellow-orange, C+ orange, Pd-; thiophaninic and stictic acids.

Specimens examined.
AUSTRALIA, QUEENSLAND. Burleigh Heads N. P., *J. A. Elix 1115*, 22.viii.1975 (ANUC); Herberton Rd., 2 km SW of Atherton, on *Casuarina*, *J. A. Elix 16168*, 24.vi.1986 (ANUC); Conway State Forest, 18 km E of Proserpine, on

Albizzia, J. A. Elix 20223, 28.vi.1986 (ANUC); Clarke Range, 36 km SE of Proserpine, on *Argyrodendron, J. A. Elix 20842*, 29.vi.1986 (ANUC); Robertson Park, Indooroopilly, W of Brisbane, *J. Hafellner 19263*, 16.viii.1986 (GZU); Moreton Bay, near Brisbane, on mangrove, *H. Lumbsch 5385 p.p.*, 10.vii.1987 (herb. LUMBSCH); Machans Beach, N of Cairns, on mangrove, *K. . Kalb 21191*, 26.viii.1988 (herb. KALB).
NEW SOUTH WALES. Lord Howe Island, *sin. loc., C. Hedley & W. Dunn s.n.*, 11.ix.1908 (NSW).

P. leioplacella was reported from Queensland (Shirley 1889) and Western Australia (Wilson 1890) but the specimens corresponding to these reports have not been seen.
P. syngenetica Müll.Arg. (Müller 1884), described from Brazil, is morphologically very similar to *P. leioplacella*; the holotype of *P. syngenetica* [Brazil, Apiahy, ?collector, 1883, (G)] contains stictic acid and has 8 biseriate spores per ascus, 20-25 x 45-60 µm, and is annotated "Wie P. leioplacella, spor. aber kleiner". The Müller Herbarium also contains an Australian specimen of *P. syngenetica* [(Queensland) Toowoomba, *Hartmann s.n.*, F. v. Muller 1894 (G)] but this specimen has slightly larger, uniseriate spores, 25-30 x 60-65 µm, and is identified as *P. leioplacella. P. leioplacella* is widely distributed in the Southern Hemisphere and occurs in Brazil and Paraguay (Vainio 1890:111; Malme 1936) and in South Africa (Doidge 1950:295) as well as in eastern Australia; it also occurs in Hawaii (Magnusson 1955).

Pertusaria subventosa Malme, *Arkiv för Botanik* 28A(9): 7 (1936)

Type: Brazil, Matto Grosso, Serra da Chapada, Buriti, *G. Malme 3936*, 24.vi.1894 [published as 1904]; holotype-S.

Pertusaria paeminosa A. Archer, *Nova Hedwigia* 50: 3 (1990).

Type: Australia, New South Wales, Bairne Track, *ca.* 30 km N of Sydney, on exposed sandstone, *A. Archer P 38*, 14.i.1989; holotype-NSW; isotype-CBG.

Pertusaria sorediata Knight in Shirley, *Proc. Roy. Soc. Queensland* 6: 141 (1889); nom. illeg., non *Pertusaria* *sorediata* (Fr.) Fr. 1846.

Type: Queensland: Moreton Bay, *J. Shirley 67*, no date; holotype-WELT.

Thallus off-white to greyish white, moderately thick, margin well-defined and not zoned, areolate and cracked, surface smooth, sorediate, lacking isidia, saxicolous; soralia white, conspicuous, becoming numerous and often confluent away from the margin, subspherical, sometimes becoming slightly stipitate, 0.5-1.5 mm wide; *apothecia* rare, disciform, discs dark brown, white pruinose, 0.2-0.5 mm diam., becoming exposed in stipitate soralia in groups of 1-3; asci clavate, 170-200 µm long, 50-60 µm wide; *spores* solitary, elongate ellipsoid, rarely lachrymoid, sometimes curved, 120-160 µm long, 35-50 µm wide, spore wall 1 µm thick.
Chemistry: K+ weak yellow, or rarely violet; KC+ violet; C-; Pd+ yellow or rarely Pd-; lichexanthone and thamnolic and picrolichenic acids; rarely with thamnolic acid replaced by hypothamnolic acid.

Specimens examined.
QUEENSLAND: Tip of Cape York Peninsula, *A. Filson s.n.*, 16.vii.1977 (MEL 1018913) [fertile]; Miami, South Nobby, 28°08′S, 153°30′E, *R. Rogers 2414*, 10.x.1981 (BRIU); Glasshouse Mtns., ca. 3 km S of Crookneck Mtn., 25°57′S, 152°56′E, 100 m, *J. Hafellner 15814*, 26.vii.1986 (GZU) [with hypothamnolic acid]; Mistake Mtns., near Doggs Falls, 28°20′S, 152°20′E, on basaltic rocks, *H. Lumbsch 5699b*, 29.ix.1987 (CBG, herb. LUMBSCH, NSW).
NEW SOUTH WALES: Sydney, South Head, *E. Cheel 52*, 26.v.1901 (NSW L4446); Currowan State Forest, 12 km W of Nelligen, *J. A. Elix 3579*, 7.vii.1977 (ANUC) [fertile]; Springwood, Sassafras Creek, 65 km W of Sydney, 33°43′S, 150°34′E, 250 m, *A. Archer P17*, 5.viii.1988 (GZU, NSW).
AUSTRALIAN CAPITAL TERRITORY: Gudgenby Gorge, 27 km S of Canberra, 35°37′S, 149°07′E, 700 m, *H. Lumbsch 5629b*, 1987 (CBG, herb. LUMBSCH, M, NSW).

Pertusaria paeminosa (Archer 1990) was recently described as a saxicolous and corticolous species from eastern Australia; the saxicolous material however is morphologically and chemically identical with the previously described *P. subventosa* Malme (Malme 1936). No spores were reported for the South American material and an amended description of the species is therefore given above. The corticolous specimens of *P. paeminosa* are now considered to be a separate species, here described as *P. scaberula, sp. nov. (vide supra)*. *P. subventosa* is a common, conspicuous white crustose lichen in the Great Dividing Range and the coastal region in eastern Australia and may cover large areas on exposed sandstone and other rocks. It is often found with the saxicolous *P. persulphurata* Müll.Arg.

Pertusaria xanthostoma (Somm.) Fr., *Lich. Europ. Reform.*: 426 (1831)
Porina xanthostoma Somm., *Kongl. Vetensk. Acad. Handl.*(1823): 115 (1824).

Type: Norway, Nordland, Bodoe, in cortice *Juniperi*, *Sommerfelt s.n.*, 1822; O-holotype (fide Dibben 1980: 121). n.v.
A detailed description of the species is given by Dibben (*loc. cit.*).
Chemistry: K-, KC+ red, C-, Pd-; alectoronic acid.

Specimens examined.
AUSTRALIA. Tasmania, Mt. Dromedary, 42°43′S, 147°06′E, 990 m, on soil in rock crevices, *G. Kantvilas 679/90*, 1.xii.1990 (HO 127257).
NEW ZEALAND. [South Island], southern slopes of Foggy Peak, Torlesse Range [W of Christchurch], 1010 m, on dead tussock grass in alpine heath, *J. A. Elix 7656, 7660*, 23.iii.1980 (ANUC); Torlesse Range, Canterbury, *H. Mayrhofer 9004*, 22.i.1985 (GZU).

P. xanthostoma was first described from Norway and is also known from Alaska, Greenland, Iceland, Scotland and western Russia; it is reported to be humicolous and muscicolous as well as corticolous (Dibben loc.cit.). The species is characterised by the pale yellow brown ostioles, the four-spored asci and the presence of alectoronic acid.

PRELIMINARY KEY TO THE AUSTRALIAN *PERTUSARIA*.

The detailed morphology, chemistry and synonymy of taxa in the key that are not described in this paper have been published elsewhere (Archer 1991, Galloway 1985, Kantvilas 1990). The key contains 63 taxa.

1. Thallus corticolous (rarely muscicolous). 2
1a. Thallus saxicolous. 57

2. Thallus sorediate, or isidiate, or pustulate or with sterile discs. 3
2a. Thallus with fertile papillae, discs or verrucae; with or without isidia or soralia. 15

3. Thallus sorediate or isidiate. 10
3a. Thallus pustulate or with sterile discs. 4

4. Thallus with sterile discs. 5
4a. Thallus pustulate, usually with exposed medulla. 8

5. Discs K+ yellow or violet, KC-. 7
5a. Discs K-, KC+ violet or red. 6

6. Discs KC+ violet, picrolichenic acid. *P. truncata* Krempelh.
6a. Discs KC+ red, lecanoric acid. *P. velata* (Turner) Nyl.

7. Discs K+ yellow, Pd+ yellow; haemathamnolic acid. *P. commutata* Müll.Arg.
7a. Discs K+ violet, Pd-, hypothamnolic acid. *P. novaezelandiae* Szatala

8. Thallus Pd+ yellow or orange; KC-. 9
8a. Thallus Pd-, KC+ violet, with picrolichenic acid. *P. lacerans* Müll.Arg.

9. Thallus K+ red, Pd+ yellow, with norstictic acid. *P. sublacerans* Archer
9a. Thallus K-, Pd+ orange, with protocetraric acid. *P. lacericans* Archer

10. Thallus sorediate, with soralia. 11
10a. Thallus isidiate. 14

11. Soralia white, K+ yellow, red or violet; KC-. 12
11a. Soralia yellow, K-, KC+ orange, with thiophaninic acid. *P. xanthosorediata* Archer

12. Soralia K+ violet, Pd-, with hypothamnolic acid. *P. novaezelandiae* Szatala
12a. Soralia K+ yellow or red, Pd+ yellow. 13

13. Soralia K+ red with norstictic acid. *P. erythrella* Müll.Arg.
13a. Soralia K+ yellow, with thamnolic acid. *P. scaberula* Archer

14. Thallus with 2′-O-methyl perlatolic acid; when fertile, 2 smooth spores/ascus. *P. isidiosa* Archer
14a. Thallus with stictic acid; when fertile, 4 rough spores/ascus. *P. subisidiosa* Archer

15.(2a). Apothecia terminal in papillae; thallus Pd+ orange-red with protocetraric acid; spores 1/ascus, 85-180 µm long. *P. gymnospora* Kantvilas
15a. Apothecia disciform or verruciform. 16

16. Apothecia disciform; spore wall single, *ca.* 1 µm thick, smooth; 1 or 8 spores/ascus. 17
16a. Apothecia verruciform; spore wall usually double, *ca.* 5 µm thick, smooth or rough, rarely single; 2, 4 or 8 spores/ascus. 27

17. Spores 1/ascus. 18
17a. Spores 8/ascus. 25

18. Thallus Pd+ yellow or orange. 19
18a. Thallus Pd-. 20

19. Thallus K+ red, Pd+ yellow, with norstictic acid; spores 150-170 µm long. *P. sublacerans* Archer

19a. Thallus K-, Pd+ orange, with protocetraric acid; spores 170-180 µm long. *P. lacericans* Archer

20. Thallus KC+ red or violet, K-. 21
20a. Thallus KC-, K+ yellow or violet. 23

21. Thallus KC+ red, with lecanoric acid; spores 110-140 (-170) µm long. *P. velata* (Turner) Nyl.
21a. Thallus KC+ violet, with picrolichenic acid. 22

22. Discs 1-2 mm diam., conspicuously concave; thallus

with atranorin; spores 150-170 µm long.
P. patellifera Archer
22a. Discs 0.5-1.5 mm diam., flat; thallus with lichexanthone; spores 110-160 µm long.
P. confusa Archer

23. Thallus K+ violet, with hypothamnolic acid; spores 90-150 µm long. *P. novaezelandiae* Szatala
23a. Thallus K+ yellow. 24

24. Discs adnate on thallus; thallus with haemathamnolic acid; spores 100-135 µm long.
P. commutata Müll.Arg.
24a. Discs on verrucae-like swellings; thallus with thamnolic acid; spores 100-112(-130) µm long.
P. miscella Archer

25. Discs KC-, K-, pale orange-pink, *ca.* 0.5 mm diam.; spores 24-40 µm long; no lichen compounds present.
P. jamesii Kantvilas
25a. Discs KC+ red or violet, K-. 26

26. Thallus KC+ violet, with picrolichenic acid; spores uncommon, 20-30 µm long. *P. truncata* Krempelh.
26a. Thallus KC+ red, with lecanoric acid; spores 50-65 µm long. *P. subrhodotropa* Archer

27.(17a) Spores 8/ascus. 28
27a. Spores 2 or 4/ascus. 41

28. Spores ellipsoid, not becoming fusiform. 29
28a. Spores fusiform, or ellipsoid becoming fusiform. 35

29. Thallus KC+, C+ orange, with thiophaninic acid. 30
29a. Thallus KC-, C-, with 4,5-dichlorolichexanthone. 33

30. Thallus with thiophaninic acid only; spores biseriate, 75-95 µm long. *P. thiophaninica* Archer
30a. Thallus with thiophaninic acid & other compounds. 31

31. Thiophaninic and stictic acids present; spores >55 µm long. 32
31a. Thiophaninic acid and unidentified compound present; spores 48-55 µm long. *P. confluens* Müll.Arg.

32. Ostioles conspicuous, bright yellow; hypostictic

acid present; spores irregularly uniseriate, 55-85 µm long.
P. meridionalis var. *xanthostoma* Müll.Arg.

32a. Ostioles inconspicuous, dark; hypostictic acid absent; spores irregularly biseriate, 55-75 µm long. *P. leioplacella* Nyl.

33. Thallus K+ red, with norstictic acid; spores uniseriate, 70-95 µm long. *P. norstictica* Archer

33a. Thallus K-, lacking norstictic acid. 34

34. Thallus with stictic acid and 4,5-dichloro-lichexanthone; spores irregularly uniseriate, 55-80 µm long. *P. leiocarpella* Müll.Arg.

34a. Thallus with 2′-O-methylperlatolic acid and 4,5-dichloro-lichexanthone; spores uniseriate, 40-65 µm long. *P. gibberosa* Müll.Arg.

35.(28a) Spores predominantly biseriate. 36

35a. Spores predominantly uniseriate. 39

36. Thallus Pd + yellow or red. 37

36a. Thallus Pd -. 38

37. Thallus K+ red, Pd+ yellow, with 4,5-dichloro-lichexanthone and norstictic acid; spores irregularly uni- or biseriate, 67-85 µm long.
P. undulata Müll.Arg.

37a. Thallus K-, Pd+ orange-red, with protocetraric acid; spores biseriate, 70-95 µm long.
P. errinundrensis Archer

38. Thallus with yellow soralia and thiophaninic and stictic acids; spores 60-65 µm long.
P. xanthosorediata Archer

38a. Thallus esorediate, with lichexanthone and stictic acid; spores 100-140 µm long.
P. dehiscens Müll.Arg.

39. Thallus lacking lichen compounds; spores 70-110 µm long; *P. subrigida* Müll.Arg.

39a. Thallus with lichen compounds; all chemical tests negative. 40

40. Lichexanthone and 2-O-methylperlatolic acid; spores always fusiform, 75-105 µm long.

P. leucostigma Müll.Arg.

40a. Thallus with 4,5-dichloro-lichexanthone and 2′-O-methylperlatolic acid; spores ellipsoid to fusiform, 75-100 μm long. *P. paragibberosa* Archer

41.(27a) Spores 4/ascus. 42

41a. Spores 2/ascus. 47

42. Spores ellipsoid, smooth or rough. 43

42a. Spores fusiform, rough, 80-110(-125) μm long, uniseriate; 4,5-dichloro-lichexanthone, 2-O-methyl- and/or 2′-O-methylperlatolic acids. *P. elliptica* Müll.Arg.

43. Spores ellipsoid, smooth. 44

43a. Spores ellipsoid, rough; thallus isidiate with stictic acid; spores 82-95 μm long. *P. subisidiosa* Archer

44. Thallus K+ red, with thiophaninic acid, and norstictic acid or 2-O-methylperlatolic acid; spores 70-110 μm long. *P. trimera* (Müll.Arg.) Archer

44a. Thallus K-. 45

45. Thallus KC+ red, with alectoronic acid; spores thin-walled, 65-85 μm long; muscicolous and humicolous. *P. xanthostoma* (Somm.) Fr.

45a. Thallus KC-; spores thick-walled. 46

46. Spores usually < 100 μm long; ostioles black, conspicuous; thallus with stictic acid; spores 75-87 μm long. *P. abberans* Müll.Arg.

46a. Spores usually > 100 μm long; ostioles hyaline, inconspicuous; thallus with 2′-O-methyl perlatolic acid ± 4,5-dichlorolichexanthone ± stictic acid; spores 90-125(-150) μm long. *P. hermaka* Archer

47. Spores ellipsoid, smooth or rough. 48

47a. Spores fusiform, smooth. 55

48. Spores ellipsoid and smooth. 49

47a. Spores ellipsoid and rough. 53

49. Thallus Pd+ yellow or orange-red. 50

49a. Thallus Pd-, lacking norstictic or protocetraric acids. 51

50. Thallus K+ red, Pd+ yellow, with norstictic and 2′-O-methylperlatolic acids; spores 120-170(-200) µm long. *P. hartmannii* Müll.Arg.
50a. Thallus K-, Pd+ orange-red, with protocetraric acid; spores (100-)125-175 µm long. *P. wilsonii* var. *aphelospora* Archer

51. Thallus pale yellow, KC+ orange, C+ orange, with thiophaninic and stictic acids; spores 80-110(-120) µm long. *P. thiospoda* Knight
51a. Thallus not pale yellow, KC-, C-, lacking thiophaninic acid. 52

52. Ostioles inconspicuous, pale to dark brown; thallus with 4,5-dichlorolichexanthone and stictic acid; spores 100-140(-160) µm long. *P. plicatula* Müll.Arg.
52a. Ostioles conspicuous, black, pseudolecideine; thallus lacking lichen compounds; spores 85-110 µm long. *P. atropunctata* Archer

53. Thallus Pd+ orange-red, with protocetraric acid; spores (110-)125-180 µm long. *P. wilsonii* Archer
53a. Thallus Pd-. 54

54. Thallus with 4,5-dichlorolichexanthone and 2′-O-methylperlatolic acid; ostioles black, punctiform; spores 95-120 µm long. *P. trachyspora* Archer
54a. Thallus with thiophaninic and stictic acids; ostioles pale, translucent; spores 80-120 µm long. *P. schizostomella* Müll.Arg.

55.(47a) Thallus and verrucae isidiate with lichexanthone ± stictic acid ± 2′-O-methyl perlatolic acid; spores 100-112 µm long. *P. isidiosa* Archer
55a. Thallus and verrucae not isidiate. 56

56. Ostioles black, conspicuous; thallus KC-, with 4,5-dichloro-lichexanthone; spores (120-)130-155 µm long. *P. irregularis* Müll.Arg.
56a. Ostioles translucent, inconspicuous; thallus KC+ orange, with thiophaninic and stictic acids present; spores 125-150(-180) µm long. *P. epacrospora* Archer

57(2a, saxicolous). Thallus sorediate, or isidiate, or with disciform apothecia; spore wall single, smooth. 58

57a. Thallus esorediate, lacking isidia, with verruciform apothecia; spore wall double, smooth or rough. 63

58. Thallus with numerous disciform apothecia; K+ red, with norstictic acid; spores 30-45 µm long. *P. concava* Müll.Arg.

58a. Thallus sorediate or isidiate. 59

59. Thallus isidiate; Pd+ orange, with salazinic acid; sterile. *P. pseudodactylina* Archer

59a. Thallus sorediate. 60

60. Thallus white or off-white, lacking thiophaninic acid. 61

60a. Thallus yellow or dull yellow, with thiophaninic acid. 62

61. Thallus white, KC+ violet, Pd+ yellow, K+ yellow, with lichexanthone, picrolichenic and thamnolic acids (or rarely Pd- and K+ violet, with hypothamnolic acid). *P. subventosa* Malme

61a. Thallus off-white, KC-, Pd+ red, K-, with atranorin and fumarprotocetraric acid. *P. sordida* Archer

62. Thallus yellow, lacking hypostictic acid. *P. persulphurata* Müll.Arg.

62a. Thallus dull yellow, with hypostictic acid. *P. remota* Archer

63.(57a) Spores 8/ascus. 64

63a. Spores 2 or 4/ascus. 72

64. Spores ellipsoid. 65

64a. Spores subfusiform to fusiform, uniseriate, 70-80 µm long; thallus with thiophaninic and 2-O-methyl perlatolic acids. *P. leucoxantha* Müll.Arg.

65. Thallus yellow. 66

65a. Thallus not yellow. 67

66. Ostioles 1/verruca, inconspicuous, flat; spores uniseriate, 50-75 µm long; thallus with thiophaninic acid. *P. xanthoplaca* Müll.Arg.

66a. Ostioles 1-4/verruca, conspicuous, subpapilliform; spores biseriate, 60-85 µm long; thallus with thiophanic acid. *P. thula* Archer

67. Thallus lacking lichen compounds; ostioles conspicuous, black, sunken; spores 37-55 µm long. *P. paratropa* Müll.Arg.
67a. Thallus with lichen compounds. 68

68. Spores >50 µm long. 69
68a. Spores 30-36 µm long; ostioles large, disc-like, conspicuous; thallus with stictic acid. *P. macra* Müll.Arg.

69. Spores >85 µm long; spores uniseriate, 85-100 µm long; thallus with 2-O-methylperlatolic acid and lichexanthone. *P. consanguinea* Müll.Arg.
69a. Spores <85 µm long. 70

70. Spores biseriate, 65-72 µm long; thallus off-white with arthothelin. *P. crassilabra* Müll.Arg.
70a. Spores uniseriate, thallus pale fawn. 71

71. Thallus KC+ orange, with thiophaninic acid and lichexanthone; ostioles black, inconspicuous; spores 60-85 µm long. *P. petrophyes* Knight
71a. Thallus KC-, with 4,5-dichlorolichexanthone and 2´-O-methyl perlatolic acid; ostioles black, conspicuous; spores 45-75 µm long. *P. lophocarpa* Körber

72.(63a) Spores 4/ascus, 85-105 µm long; 4,5-dichlorolichexanthone and stictic acid. *P. trevethensis* Archer
72a. Spores 2/ascus. 73

73. Thallus K-, with 4,5-dichlorolichexanthone and stictic acid; spores ellipsoid, smooth, 150-175 µm long. *P. vulpina* Archer
73a. Thallus K+ red, with 4,5-dichlorolichexanthone and norstictic acid; spores ellipsoid, rough, 150-200 µm long. *P. subverrucosa* Nyl.

Note: *P. leucostomoides* Zahlbr., *P. leucothelia* Müll.Arg. and *P. woollsiana* Müll.Arg. are omitted as they appear to be forms of *P. leiocarpella* Müll.Arg., *P. elliptica* Müll.Arg. and *P. gibberosa* Müll.Arg. respectively.

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RECORDS OF CRUSTOSE LICHENS FROM TASMANIAN RAINFOREST

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Abstract: Descriptive notes, comparative discussion and ecological notes are provided for 24 poorly known or previously unrecorded crustose lichens from Tasmanian cool temperate rainforest.

Introduction

Despite their undisputed abundance and diversity in Tasmanian cool temperate rainforest, corticolous crustose lichens in this habitat and in Australasia generally remain poorly known. Substantial advances in their taxonomy were made in the 19th century, with many new species being described, for example, by Jatta (1911), Müller Argoviensis (1882, 1895), Shirley (1894), Stirton (1876, 1898) and others. However, much of this work has long been neglected or overlooked and part of the task to be undertaken currently is to correlate taxa described by these early workers with recent collections.

Galloway (1985) provides descriptions of many New Zealand species, several of which have since been discovered in Tasmania. A few small, unrelated groups have been monographed, e.g. the Caliciales (Tibell 1987), *Chiodecton* (Thor 1990), *Chrysothrix* (Laundon 1981), *Haematomma* (Rogers 1982), *Leproloma* (Laundon 1989), the Megalosporaceae (Sipman 1983) and *Psilolechia* (Coppins & Purvis 1987), but the relevant taxa from these groups represent only a minor component of the rainforest flora. More recently, the Tasmanian rainforest species of *Pertusaria*, a conspicuous component of the flora, were revised by Kantvilas (1990a).

Crustose lichens occur in virtually all rainforest microhabitats with the major exception being the forest floor which is inhabited mainly by bryophytes or occasional macrolichens. Most species are epiphytes and occur directly on bark or, more rarely, over bryophytes. The richest habitats include smooth-barked trunks or twigs, especially in the canopy, and trees such as *Eucryphia* and *Atherosperma* support particularly diverse communities. Crustose lichens are also very rich in species on the old, very dry, fissured trunks of *Nothofagus cunninghamii*, the dominant tree in most forest types (Kantvilas 1988b).

In this paper, we present descriptive and ecological notes on 24 crustose species from various genera, several of which are recorded from Tasmania for the first time. The work complements our recent studies on Tasmanian rainforest macrolichens (Kantvilas *et al.* 1985, Kantvilas & James 1987) and is the precursor to further accounts in preparation on this much-neglected component of the rainforest biota.

Methods

Data are based mainly upon extensive collections of crustose lichens compiled by the senior author during investigations of cool temperate rainforest communities throughout Tasmania. Comparisons were made with either type or reliably identified material. All listed specimens refer to collections from Tasmania, located in HO, BM and some other herbaria. Chemical analyses follow the standard techniques outlined by Culberson (1972) and White & James (1985).

The Species

1. *Bacidia buchananii* (Stirton) Hellbom

Bihang K. Sv. Vet-Akad. Handl. 21, *afd* III (13): 98 (1896). - *Stereocaulon buchananii* Stirton, *Trans. N.Z. Inst.* 7: 368 (1875); type: New Zealand, "prope Wellington", rec'd 18.ix.1874, *J. Buchanan* (GLAM - lectotype [*fide* Lamb 1954]; BM! - isolectotype).

Although widespread, this species is uncommon in rainforest where it occurs mostly in deep shade on the bases of tree trunks, banks of soil, decorticated wood or, more rarely, on rocks. Its thallus resembles the primary, basal thallus of *Metus conglomeratus* but the brown, ± globose to subpedicellate apothecia and filiform, multiseptate spores, 140-170(-210) x 2-4 μm, are diagnostic. A full description and synonymy is given by Galloway (1985: 29). *Bacidia buchananii* also occurs in New Zealand, Chile and mainland Australia.

Selected specimens examined: Corinna, on *Nothofagus cunninghamii*, 80 m, 10.ii.1982, *Kantvilas* 67/82 (HO, BM). Mt Victoria Track, on *Leptospermum lanigerum*, 950 m, 8.xii.1981, *Kantvilas* 1088/81 (HO, BM). Little Fisher River, on *Leptospermum lanigerum*, 820 m, 17.viii.1982, *Kantvilas* 213/82 (HO, BM).

2. *Bacidia weymouthii* (Shirley) Zahlbr.

Catal. Lich. Univ. 4: 248 (1927). - *Patellaria weymouthii* Shirley, *Pap. Proc. R. Soc. Tasm.* 1893: 217 (1894); type: Tasmania, St Crispins, Mt Wellington, on bark, 10.ii.1891, *W. A. Weymouth* 112 (BRI! - lectotype [*fide* Kantvilas 1988a]; MEL! - isolectotype).

Figure 1a-b.

Thallus crustose, thin, mottled whitish grey, cream or brownish green, in patches up to *c.* 5 cm wide, often surrounded by a black prothallus. *Apothecia* lecideine, to 0.8 mm diameter, black, glossy, occasionally proliferating with clusters of superficial, smaller apothecia; margin flexuose, persistent; disc plane, becoming convex with age. *Epithecium* black to dark olivaceous brown, ± granular, granules not dissolving in K. *Hymenium* colourless, containing numerous oil droplets, 70-80 μm thick, unchanged in K. *Hypothecium* colourless to pale brown in the lower part, 80-100 μm thick, unchanged in K. *Exciple* opaque, purple-blackish or dark brown, sometimes tinged greenish black at edges, K± greenish blue. *Paraphyses* simple, 1.0-1.5 µm thick, ± conglutinate in K, apices to *c.* 2 µm thick, olivaceous to pale grey-purple, colour intensifying or greenish in K. *Asci* 48-65 x 12-19 µm, wall and thickened apices I+ blue. *Spores* hyaline, curved, acicular with acuminate apices, rather broader at one end, 41-52 x 3.5-6(-7) µm, very indistinctly 4-6 septate, spiralled in the ascus. *Pycnidia* not seen. *Chemistry:* atranorin (± trace).

Bacidia weymouthii is a distinctive species, apparently endemic to Tasmania. It is a widespread pioneer on smooth-barked, shaded trunks and twigs, particularly *Atherosperma moschatum*, and is commonly associated with *Thelotrema lepadinum*, *Coccotrema cucurbitula*, *Phlyctis subuncinata* and *Arthothelium interveniens*. Although Shirley (1894) states that the spores of this species are 26-30 x 2-2.5 µm, an examination of his type material revealed they were significantly larger.

Selected specimens examined: Simons Road near Ben Nevis, on *Atherosperma moschatum*, 830 m, 7.xii.1981, *Kantvilas* 1083/81 (HO, BM). Five Road, Florentine Valley, on *Atherosperma moschatum*, 450 m, 10.iv.1981, *Kantvilas* 240/81 (HO, BM). Meander Forest Reserve, on *Atherosperma moschatum*, *c.* 800 m, 19.vii.1984, *Kantvilas* 669/84, (HO, BM).

3. ***Catillaria kelica*** (Stirton) Zahlbr.

Catal. Lich. Univ. 4: 49 (1926). - *Lecidea kelica* Stirton, *Rep. Trans. Glasgow Field Nat.* 1: 18 (1873); type: New Zealand, near Wellington, *J. Buchanan* 178 (BM! - lectotype [*fide* Galloway 1985]).

This species is common and widespread in rainforest on the lower trunks and branches of trees with smooth bark, especially *Atherosperma*, *Cenarrhenes* and *Tasmannia*. It is recognised by its bright mustard-yellow, immarginate apothecia and 1-septate, ellipsoid spores with pointed apices, 12-18 x (4-)5-6 µm. A full description is provided by Galloway (1985: 76). Some older specimens may have blackened apothecia but careful examination usually reveals some hint of their diagnostic yellow colour. The species also occurs in New Zealand and Victoria.

In the present paper, the genus *Catillaria* is applied in a very broad heterogeneous sense and, with further study, it is likely that *C. kelica* will need to be transferred to another genus (D.J. Galloway *in litt.*). The species has non-halonate spores, branched paraphyses without thickened apices, and asci with an amyloid tholus, small occular chamber and *masse axiale*, suggesting closer relationships with the Bacideaceae or Biatoraceae (*sensu* Hafellner 1984).

Selected specimens examined: Lyons River, on *Nothofagus cunninghamii*, 280 m, 21.i.1982, *Kantvilas* 25/82 (HO, BM). Adamsons Road, near Strathblane, on *Tasmannia lanceolata*, 100 m, 4.xii.1981, *Kantvilas* 1072/81 (HO, BM). Sumac Road, Spur 2, south of Arthur River, on *Cenarrhenes nitida*, 170 m, 12.v.1981, *Kantvilas* 355/81 (BM, HO). Weldborough, on *Atherosperma moschatum*, 640 m, 17.xii.1981, *Kantvilas* 1189/81 (HO, B).

4. *Catillaria pulverea* (Borrer) Lettau

Hedwigia 52: 136 (1912). - *Lecidea pulverea* Borrer in Hook. & Sowerby, *Engl. Bot. Suppl.* 2: tab. 2726 (1834); type: British Isles, New Forest, *C. Lyall* (BM! - holotype).

Catillaria pulverea occurs mostly on mature trunks in clearings in high altitude forests and wet scrub. Some specimens are virtually esorediate and richly fertile whilst others are sterile and almost entirely sorediate. Although easily overlooked, the species can be recognised by its pale, glaucous green to grey, coarsely granular sorediate thallus and diagnostic chemistry of fumarprotocetraric acid, atranorin and zeorin (thallus K+ yellow, PD+ red). Its dark brown to black apothecia with thin, pale grey, ± translucent margin are also diagnostic, as is the ± opaque greenish to violaceous black, K+ aeruginose epithecium. Spores are ellipsoid, non-halonate, 1-septate, 15-21(-25) x 5-9 µm. Originally described from England, the species is also known from New Zealand (see Galloway 1985: 78 for complete description).

Selected specimens examined: Ben Ridge, on *Notelaea ligustrina*, 860 m, 13.ii.1981, *Kantvilas* 43/81 (HO, BM). Weldborough, on *Monotoca glauca*, 640 m, 18.xii.1981, *Kantvilas* 1180/81, (HO, herb. Vězda). Little Fisher River, on *Nothofagus cunninghamii*, 820 m, 20.x.1984, *Kantvilas* 699/84 (HO, herb. Vězda, BM).

5. *Catillaria tasmanica* Räsänen

Suomal. eläin-ja Kasvit, Seur van Julk. 21: 3 (1944); type: Tasmania, "prope Newtown Falls, corticola", 18.iii.1887, *R. A. Bastow* (G! - holotype).

Figure 1c-d.

Thallus crustose, pale to dark grey, mostly rather thin, ± smooth, somewhat patchy. *Photobiont* green, unicellular, irregularly globose, (6.5-)9-14 µm diam. *Apothecia* lecideine, to 2mm diameter; disc black, rarely rather pallid when very young or in shade, matt, plane, becoming ± convex with age; margin black, thick at first but ± excluded in oldest apothecia. *Exciple* colourless within, greenish black at the upper, outer edge, composed of loosely interwoven, branched hyphae, 1.2-1.5 µm thick. *Epithecium* dark green-grey to brown-black, rarely with a ± purplish tinge, ± intensifying greenish in K. *Hymenium* colourless to very pale yellow-brown, (75-)90-130(-200) µm thick, unchanged in K; asci with ± uniformly amyloid tholus. *Paraphyses* simple to sparingly branched, twisted, *c.* 1.0 µm thick, apices not or slightly expanded to 1.5 µm thick. *Hypothecium* colourless to very pale yellow-brown, occasionally with irregular bands greenish grey, intensifying greenish in K, 120-200 µm, rarely massive. *Spores* hyaline, non-halonate, broadly ellipsoid, with rounded apices, 1-septate, (17-)20-32(-38) x 9-14(-17) µm, wall to 1.5 µm thick. *Pycnidia* unknown. *Chemistry:* atranorin.

Catillaria tasmanica is very common on smooth bark on twigs and young trunks in rainforest and wet sclerophyll forest, particularly at altitudes above *c.* 600 m. It is very variable, especially regarding spore size which may range from 20-25 µm long in some specimens to *c.* 30-38 µm in others. However, this variation is exhibited by the type specimen, albeit in different apothecia. Specimens from shaded habitats tend to have a

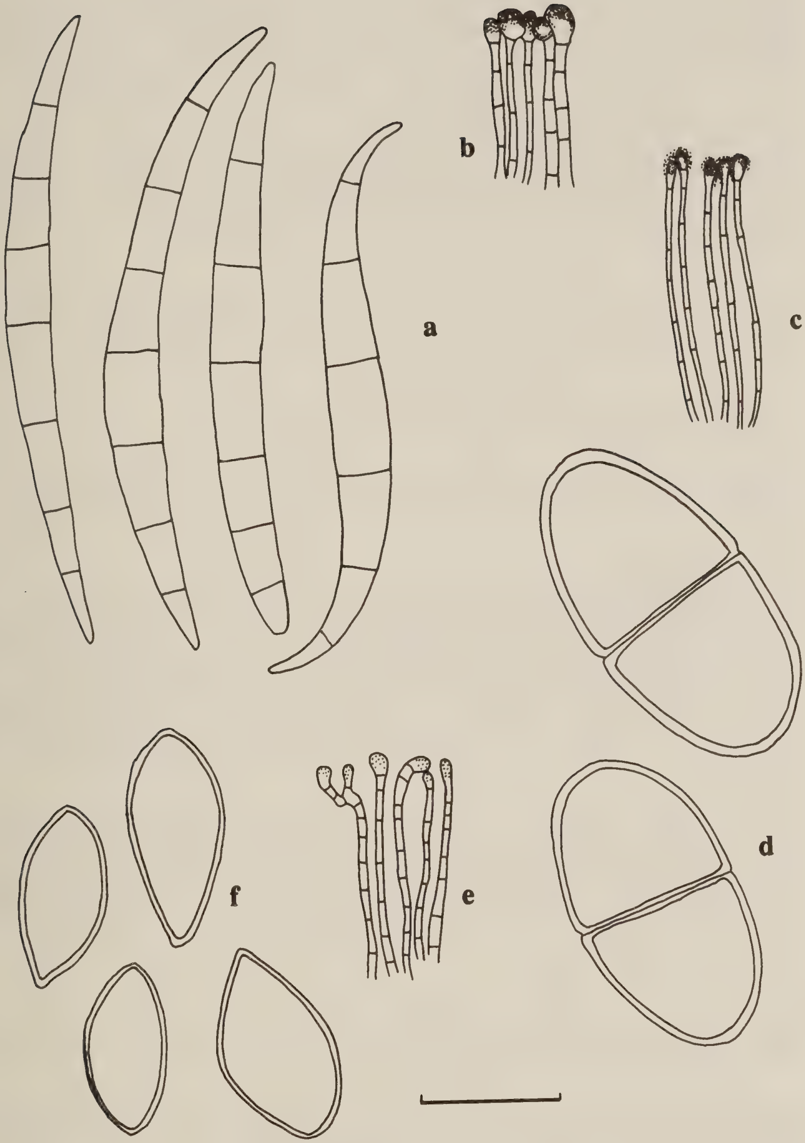

FIGURE 1. Spores and apices of paraphyses. a, b: *Bacidia weymouthii*; c, d: *Catillaria tasmanica*; e, f: *Lecidea immarginata*. Scale = 10 µm.

thin thallus and partly pallid apothecia with thin margins. Those from exposed habitats (e.g. the type) have jet-black apothecia with prominent margins; a continuum of variation can be found between these extremes. Superficially *C. tasmanica* resembles *Megalaria grossa* but differs in the internal colouration of the apothecial tissues (e.g. *M. grossa* has a blue-black hypothecium) and in its ecology (*M. grossa* is found mostly amongst bryophytes on thick fibrous bark). It is also similar to the New Zealand species *Catillaria corroborans* (Stirton) Zahlbr. (see Galloway 1985:75) which differs chiefly by its black or brown-black hypothecium (D.J. Galloway *in litt.*) *Catillaria tasmanica* is also known from cool temperate rainforest in N.S.W. where it is rare (Kantvilas 1990b).

Selected specimens examined: Telopea Road near Ben Nevis, on *Telopea truncata*, 870 m, 5.xi.1980, *Kantvilas* 544/80 (HO, herb. Vězda, BM). Little Fisher River, on *Nothofagus cunninghamii*, 820 m, 23.iv.1982, *Kantvilas* 111/82 (HO, BM). Lake Highway near Projection Bluff, on *Nothofagus cunninghamii*, 980 m, 1.v.1980, *Kantvilas* 169/80 (HO, BM).

6. *Graphis insidiosa* (Knight & Mitten) J.D. Hooker

Handbook N.Z. Fl.: 586 (1867). - *Fissurina insidiosa* Knight & Mitten, *Trans. Linn. Soc. Lond.* 23: 102 (1860); type: New Zealand, *sine loco*, ?Auckland, *Charles Knight* 259 (BM! - lectotype [*fide* Hayward 1977]).

Graphis insidiosa is recognised by its pale fawn, non-carbonised lirellae and non-amyloid, 4-locular spores, 18-27 x 8-10(-12) µm (see Hayward 1977 for full description and illustrations). It contains no substances detectable by t.l.c. The species is highly variable and lirellae may be immersed or emergent, short, simple and scattered, or curved, serpentine and occasionally branched. *G. insidiosa* is widespread in Tasmanian rainforest on rough and smooth bark, particularly on *Nothofagus cunninghamii*, mostly in deep shade. It is also known from New Zealand Hayward (1977), southern United States and Dominica (Wirth & Hale 1978).

Selected specimens examined: South of Meunna, on *Nothofagus cunninghamii*, 370 m, 16.ii.1982, *Kantvilas* 53/82 (HO, B, BM). Tayatea Rd, south of Little Rapid River, on *Nothofagus cunninghamii*, 230 m, 18.ii.1982, *Kantvilas* 69/82 (HO, BM). Sumac Road, Spur 2, south of Arthur River, on *Nothofagus cunninghamii*, 170 m, 19.v.1981, *Kantvilas* 316/81 (HO, BM).

7. *Graphis librata* Knight

Trans. N.Z. Inst. 16: 404 (1884); type: New Zealand, *sine loco*, ?Wellington, *Charles Knight* 67: 23 (WELT! - lectotype [*fide* Hayward 1977]).

Graphis librata belongs to the *G. scripta* complex which is characterised by a basally open, carbonised exciple and 5-9 locular spores in the 20-40 µm range (Wirth & Hale 1978). These authors consider *G. scripta* (L.) Ach. *s.str.* a strictly temperate northern hemisphere taxon and, on that basis, that name appears to have been misapplied in the Australasian literature in the past. *G. librata* is recognised by its whitish grey thallus, black, curved, serpentine lirellae, usually with a thalline margin, amyloid, 5-9 (usually 7)-locular spores, 16-26 x 6-9 µm and by the presence of norstictic acid. It occurs on the lower, shaded trunks of trees with smooth bark, especially *Atherosperma moschatum.* However, several specimens are morphologically and anatomically identical to *G. librata s.str.* but lack norstictic acid (which is replaced by two unidentified compounds). *G. librata* is also known from New Zealand, New South Wales and the Caribbean (see Hayward 1977, Wirth & Hale 1978 and Kantvilas 1990b for further details).

Selected specimens examined: (i) *with norstictic acid:* Savage River Pipeline, on *Anodopetalum biglandulosum*, 480 m, 27.xi.1980, *Kantvilas* 716/80 (LSU, HO, B, BM). Corinna, on *Nothofagus cunninghamii*, 80 m, 10.ii.1982, *Kantvilas* s.n. (HO). (ii) *containing unidentified substances:* Five Road, Florentine Valley, on *Atherosperma moschatum*, 450 m, 9.viii.1980, *Kantvilas* 288/80 (HO, ASU, BM). Ben Ridge Road, on *Atherosperma moschatum*, 850 m, 10.xii.1981, *Kantvilas* 1115/81 (HO, BM).

8. ***Lecanactis abietina*** (Ach.) Körber

Syst. Lich. Germ.: 276 (1855). - *Lichen abietinus* Ach., *Kgl. Vetensk. Akad. Nya. Handl.*: 139 (1795).

Known hitherto mainly from the temperate Northern Hemisphere, *Lecanactis abietina* is widepread in Tasmanian rainforest where it is confined to the very dry, fissured bark of mature, inclined trunks of *Nothofagus cunninghamii.* There it is usually associated with *Sagenidium molle*, *Chaenotheca brunneola* and species of *Lepraria.* The species forms widespreading pale grey thalli, often with a pinkish tinge. Most specimens are abundantly fertile with apothecia to 1.5 mm diameter having black margins and densely yellowish-grey pruinose discs. Spores are 3-septate, fusiform and slightly curved, (22-)26-36 x 3.5-6 µm. In such specimens, the formation of the characteristic white-pruinose cylindrical pycnidia, *c.* 0.2 mm diameter, with ellipsoid conidia, 11-15 x 4.5 µm, is totally suppressed or confined to the periphery of the thallus. However, occasional thalli are sterile and completely covered with pycnidia, a situation also found in European specimens. In the British Isles, this species may also occur occasionally on bryophytes or directly on rock but in Tasmania it appears to be strictly corticolous or lignicolous.

Selected specimens examined: Little Fisher River, on old dry *Nothofagus cunninghamii*, 820 m, 15.ii.1984, *Kantvilas & James* 429/84 (HO, BM). Styx Rd, near Carpenter Creek, on rotting stump of *Nothofagus cunninghamii*, 560 m, 17.vi.1984, *Kantvilas* 653/84 (HO, BM). Boyd Lookout, on old *Nothofagus cunninghamii*, 550 m, 11.viii.1981, *Kantvilas & James* 547/81 (HO, BM). Adamsons Falls track, on dead *Nothofagus cunninghamii*, 25.ix.1981, *Kantvilas* 965/81 (HO, B, GZU)

9. ***Lecidea immarginata*** R.Br. ex Crombie

J. Linn. Soc. Lond. Bot. 17: 400 (1880); type: Australia, New South Wales, banks of Grose River, amongst mosses on the bark of trees, *R. Brown* 591 (BM! - holotype).

Figure 1e-f.

Thallus crustose, thin, effuse, pale greenish grey, in spreading patches to 70 mm wide or more. *Apothecia* lecideine, to 1 mm diam.; disc pale to reddish brown, sometimes ± piebald, matt, plane when young, becoming convex with age; margin thin, concolorous with or slightly darker than disc, persistent except in oldest, most convex apothecia. *Hymenium* colourless, K-, 70-100 µm thick. *Hypothecium* colourless, K-, to 400 µm thick. *Exciple* colourless within, reddish brown, K- at outer edge, composed of loosely interwoven anastamosing hyphae *c.* 0.8-1.0 µm thick. *Paraphyses* sparingly branched, 1-1.5 µm thick, with slightly expanded apices, 1.5-2 µm thick, pigmented reddish brown, K-. *Asci* 50-80 x 18-22 µm, with tholus I+ blue (*Biatora*-type). *Spores* simple, hyaline, ellipsoid, non-halonate, with rounded or slightly pointed ends, 12-18 x 7-12 µm. *Pycnidia* not seen. *Chemistry:* thallus PD-, K-, KC-, C-, UV- (no substances detected by t.l.c.).

Lecidea immarginata is an uncommon species occurring on shaded trunks and branches with smooth bark. It is found mostly on *Atherosperma* where it is associated with *Thelotrema lepadinum, Phlyctis subuncinata* and species of *Arthothelium* and *Pyrenula.* It is rather similar to an undetermined species of *Lecidea* s.lat. with smaller (to 0.8 mm diam.) apothecia and ellipsoid - fusiform spores, 9.5-12 x 2.5-4 µm.

Selected specimens examined: Styx Road, Styx Valley, on *Atherosperma moschatum*, 370 m, 27.xi.1981, *Kantvilas* 1034/81 (HO, BM). Near Lyons River, on *Atherosperma moschatum*, 340 m, 21.i.1982, *Kantvilas* 23/82 (HO, BM). Weldborough, on *Atherosperma moschatum*, 640 m, 17.xii.1981, *Kantvilas* 1129/81 (HO, BM).

10. ***Lepraria lobificans*** Nyl.

Flora 56: 196 (1873).

Lepraria lobificans is common in Tasmanian rainforests in dry, sheltered microhabitats, usually in deep shade. It forms a thick, leprose, glaucous grey crust in small irregular spots or in large continuous expanses on the underhanging faces of old, inclined *Nothofagus* trunks, tree fern trunks or the undersides of large branches. The species is characterised by its thallus chemistry which includes atranorin, zeorin and stictic, constictic, peristictic, cryptostictic and norstictic (±) acids.

As elsewhere, the genus *Lepraria* is very poorly understood in Tasmania and, in the absence of reliable morphological distinguishing characters, chemistry is the soundest base for recognising most taxa at present. In addition to *L. lobificans*, several other chemical strains of *Lepraria* have been recorded. The most common contains barbatic and 4-0-demethylbarbatic acids and often occurs sympatrically with *L. lobificans.* Three other strains recorded include specimens with atranorin only, with fumarprotocetraric acid, or with fatty acids.

Selected specimens examined: Sumac Road, Spur 2, south of Arthur River, on *Nothofagus cunninghamii*, 170 m, 24.xi.1980, *Kantvilas* 649/80 (HO, ASU, BM). Ben Ridge, east of Ben Nevis, on *Atherosperma moschatum*, 850 m, 17.ii.1981, *Kantvilas* 104/81 (HO, BM). Holwell Gorge, on *Dicksonia antarctica*, 200 m, 24.v.1980, *Kantvilas* 202/80 (HO, BM, LSU, COLO).

11. ***Lopadium disciforme*** (Flotow) Vězda & Poelt

Bestimmungsschlüssel Europäischer Flechten, Erg. II: 205 (1981). - *Heterothecium pezizoideum* var. *disciforme* Flotow, *Bot. Zeitung* 8: 553 (1850).

Previously known only from the temperate Northern Hemisphere, *Lopadium disciforme* is very rare in Tasmania and known mainly from the west and north-west where it occurs mostly on mature, shaded trunks of *Nothofagus cunninghamii.* It is characterised by a thin, dark brown to olivaceous, areolate thallus and dull black, lecideine, minutely scabrid apothecia to 1 mm diameter. It has diagnostic, highly muriform, thin-walled spores, 1 per ascus, (65-)79-110 x (22-)27-38 μm and paraphyses with black, capitate apices.

Selected specimens examined: Flannel Road, Arthur River, on *Nothofagus cunninghamii*, 420 m, 19.i.1982, *Kantvilas* 14/82 (HO, BM). Tayatea Road, Spur 14, on *Nothofagus cunninghamii*, 240 m, 18.ii.1982, *Kantvilas* 292/82 (HO). Sumac Road, Spur 2, south of Arthur River, on *Nothofagus cunninghamii*, 170 m, 15.v.1981, *Kantvilas* 329/81 (HO, BM). Anthony Road, on *Cenarrhenes nitida*, 450 m, 10.v.1990, *Kantvilas* 190/90 (HO, ASU, GZU).

12. ***Lopadium hepaticola*** Döbbeler, Poelt & Vězda

Herzogia 7: 82 (1985); type: Tasmania, Mt Barrow foothills, on *Acrochila biserialis*, *S. J. Jarman* 1477 (M! - holotype).

Lopadium hepaticola is endemic to Tasmania and is known currently from only two localities, although it is extremely inconspicuous and easily overlooked. The species forms a dull film over mats of bryophytes on moist, moderately shaded tree trunks where it is associated only with poorly developed lichen thalli (e.g. species of *Micarea* or *Sphaerophorus*). *Lopadium hepaticola* has characteristic, obconical, dark brown apothecia with black discs, *c.* 0.5 mm diameter, elongate-ellipsoid, highly muriform spores 60-140(-155) x 20-45(55) μm, and simple paraphyses with capitate, black-brown apices. A full description with illustrations is provided by Döbbeler *et al.* (1985).

Specimen examined: Range Road, Florentine Valley, on dead *Phyllocladus aspleniifolius* at edge of rainforest, 14.i.1983, *Kantvilas* 139/83 (HO).

13. ***Miltidea ceroplasta*** (Church. Bab.) D. Galloway & Hafellner

Beih. Nova Hedwigia 79: 308 (1984). - *Biatora ceroplasta* Church. Bab., *Fl. N.Z.* 2: 300 (1855); type: New Zealand, *sine loco*, *Colenso* (BM! - holotype).

The genus *Miltidea* was established by Stirton (1898) to accommodate several red-fruited species of *Lecidea* s. lat. It was resurrected recently by Hafellner and Galloway who place it in the monogeneric family Miltideaceae (Hafellner 1984). *Miltidea* is characterised by a crustose thallus containing a chlorococcalean photobiont, sessile biatorine apothecia containing red anthraquinone pigment (K+ crimson), eight-spored asci surrounded by amyloid jelly , with a weakly amyloid tholus lacking any internal recognisable structures, sparsely branched paraphyses inspersed with oil bodies, and simple, hyaline, halonate spores (Hafellner 1984).

Miltidea ceroplasta is easily recognised by its large, convex to sub-globular, orange-brown, yellow-orange or red apothecia to 2 mm diameter, thin to rather thick, pale grey, white or cream thallus, and ellipsoid spores 17-25 x 7-12 μm. It is described fully by Galloway (1985: 226) and illustrated by Hafellner (1984). The diagnostic K reaction of the apothecia is variable and linked with age. Tiny, dot-like, red apothecial initials are K+ crimson. These soon develop the typical orange-brown colour, K+ crimson, but the oldest, ± globular apothecia are mostly K+ yellow in section. *M. ceroplasta* is rather similar to *Lecidea laeta*, a canopy twig species with vivid scarlet, K+ crimson, plane, ± irregularly discoid apothecia, 0.5-0.8 mm diameter and smaller, elongate spores, 9.5-13 x 3.5-5 μm.

Miltidea ceroplasta is common and widespread in Tasmanian rainforests on smooth bark on low branches or on upper trunks, but not in the canopy. Common host trees include young *Nothofagus*, *Eucryphia*, *Anodopetalum*, *Phyllocladus* and *Pittosporum*. It is also known from New Zealand and Chile.

Selected specimens examined: Mt Field National Park, on *Pittosporum bicolor*, 700 m, 23.iv.1980, *Kantvilas* 126/80 (HO, BM). Sumac Road, Spur 2, south of Arthur River, on *Phyllocladus aspleniifolius*, 170 m, 15.v.1981, *Kantvilas* 353/81 (HO, BM, B, GZU). Savage River Pipeline Road, on *Anodopetalum biglandulosum*, 410 m, 28.i.1982, *Kantvilas* 31/82 (HO, BM).

14. *Opegrapha agelaeoides* Nyl.

J. Linn. Soc. Lond. (Bot.) 9: 257 (1865); type: "Nova Zelandia, Otago, ad cortices arborum", 1861, *Dr Lauder Lindsay* (H-NYL 6110! - lectotype [*fide* Hayward 1977]).

Previously considered endemic to New Zealand (Hayward 1977, Galloway 1985), *Opegrapha agelaeoides* is here recorded for Tasmania for the first time. It is an inconspicuous, uncommon species occurring on smooth bark amongst bryophytes, typically at rainforest margins or in wet sclerophyll forest. Associated taxa include *Phlyctis subuncinata*, *Megaloblastenia marginiflexa* and *Megalospora subtuberculosa*. The species, described fully by Hayward (1977) and Galloway (1985), is recognised by its prominent lirellae, 0.4-1.5 mm long, *c.* 0.2 mm wide with convergent lips, and fusiform spores, (20-)29-36(-44) x 8-9(-12) μm with 6-8 septa and walls 1-2 μm thick. It contains no substances detectable by t.l.c.

Specimens examined: Corinna, on *Pomaderris apetala*, 10.ii.1982, *Kantvilas* s.n. (HO). Sandy Bay Rivulet beyond the Waterworks, 28.x.1910, *W. A. Weymouth* 922 (HO). Robertsons Bridge, Sandspit River, on *Pomaderris apetala*, 210 m, 10.x.1990, *Kantvilas* 329/90 (HO).

15. *Opegrapha stellata* Knight

Trans. N.Z. Inst. 16: 403 (1883); type: New Zealand, *Charles Knight* 65A: 8 (WELT! - lectotype [*fide* Hayward 1977]).

Opegrapha stellata is characterised by narrow, simple or branched, straight or curved lirellae *c.* 1-4 mm long, often occuring in stellate clusters, simple or 1-septate, ovate to ellipsoid spores, (7-)10-12(-14) x (3-)4-7 μm, and by the presence of norstictic acid, often in trace amounts only (see Hayward 1977, Galloway 1985 for further descriptions). It is a common pioneer of twigs and young trunks in deep or moderate shade, particularly on *Nothofagus cunninghamii*, *Trochocarpa gunnii* or *Anodopetalum biglandulosum*. Associated lichens include *Coccotrema cucurbitula*, *Catillaria tasmanica*, *Austroblastenia pauciseptata* and *Sarrameana tasmanica* (see Kantvilas 1988: 415). In sunnier habitats, the thallus is whitish grey but in extreme shade, the thallus tends to be greenish to ± evanescent.

Selected specimens examined: Mt Victoria Track, on *Pittosporum bicolor*, 900 m, 8.xii.1981, *Kantvilas* 1112/81 (HO, BM). Lake Highway near Projection Bluff, on *Nothofagus cunninghamii*, 980 m, 17.iii.1982, *Kantvilas* 268/82 (HO, BM). Little Fisher River, on *Nothofagus cunninghamii*, 820 m, 21.iv.1982, *Kantvilas* 108/82 (HO, BM).

16. *Opegrapha viridis* Pers. ex Ach.

Meth. Lich.: 22 (1803).

Thallus crustose, very thin, pale grey to brownish grey or dark olive-grey, rather patchy to almost absent, occasionally delimited by a black, marginal prothallus. *Lirellae* black, superficial, simple or occasionally furcate, straight or curved, 0.4-1 mm long, *c*. 0.2 mm wide, lips convergent, obscuring the disc, base closed, sometimes barely so. *Epithecium* pale brownish, K+ pale greenish grey. *Hymenium* colourless, 90-110 μm thick, I+ red. *Hypothecium* colourless to pale brown, K+ pale greenish grey. *Exciple* brownish black in section, K+ greenish black at edges. *Spores* 8 per ascus, arranged side by side, narrow fusiform, 43-72 x 5-8 μm, (11-)16-18 septate, walls *c*. 1.2 μm thick. *Chemistry:* no substances detected.

Opegrapha viridis is an inconspicuous but widespread species in Tasmanian rainforest, known from the smooth bark of *Atherosperma moschatum* and young *Nothofagus cunninghamii*. It is found mostly on the undersides of canopy twigs, associated with *Porina leptaleina*, *Scoliciosporum pruinosum*, *Menegazzia retipora* and species of *Usnea*. Less commonly the species occurs on shaded trunks. *Opegrapha viridis* is widespread in the Northern Hemisphere and further brief descriptions are provided by Duncan (1970) and Upreti & Singh (1987).

Selected specimens examined: Yarlington Tier, on *Atherosperma moschatum* and on twigs on *Nothofagus cunninghamii*, 620 m, 28.x.1987, *Kantvilas* 87/87, 88/87 (HO, BM). Balts Spur, Tasman Peninsula, on undersides of canopy twigs of *Nothofagus cunninghamii*, 420 m, vii.1983, *Kantvilas* 147/83 (HO, BM). Weindorfers Forest, on *Atherosperma moschatum*, 900 m, 28.iii.1988, *Kantvilas* 613/88 (HO). Anthony Road, on *Atherosperma moschatum*, 560 m, 16.xii.1988, *Kantvilas* 566/88 (HO).

17. *Phaeographis australiensis* Müll. Arg.

Flora 65: 504 (1882).

Descriptions and anatomical drawings of this species are given by Hayward (1977). It is recognised by the presence of norstictic acid, and its prominent lirellae with carbonised exciples and usually distinct thalline margins. Its spores are 31-50 x 7.5-10 μm with 10-12 locules and a distinct "nipple" to 5 μm long at the apices. The spores are hyaline or almost so and consequently *P. australiensis* is easily confused for a *Graphis* species, although at least some old, brownish, collapsed spores are evident in most sections.

Phaeographis australiensis occurs mostly in sclerophyll forest and is rare in rainforest where it is known from a single collection from *Eucryphia lucida*. One specimen (*Kantvilas* 116/86) lacks norstictic acid and requires further study. *Phaeographis australiensis* is also known from mainland Australia and New Zealand.

Selected specimens examined: 3 km south-east of Mt Agnew, on *Eucryphia lucida*, 190 m, 6.iv.1989, *Kantvilas* 139/89 (HO). Near Beaconsfield, on *Casuarina littoralis* in dry sclerophyll forest, 80 m, 24.v.1980, *Kantvilas* 206/80 (HO, LSU, BM). Catamaran near Ramsgate, 17.i.1911, *W. A. Weymouth* 908 (HO). Granville Harbour, on dead *Pomaderris apetala*, 20 m, 7.ii.1984, *Kantvilas & James* 249/84 (HO, BM).

18. ***Phaeographis exaltata*** (Mont. & v.d. Bosch) Müll. Arg.

Flora 65: 336 (1882). - *Lecanactis exaltata* Mont. & v.d. Bosch, *Pl. Junghuhn.* 4: 475 (1857).

Phaeographis exaltata is a widespread pantropical species, common in Tasmanian rainforest on smooth bark in moderate shade. Common phorophytes include *Anodopetalum biglandulosum*, *Nothofagus cunninghamii*, *Cenarrhenes nitida* and *Eucryphia lucida*. Elsewhere in Australasia it is also known from rainforests in New Zealand (Hayward 1977) and New South Wales (Kantvilas 1990b).

The species is characterised by a rather thick, grey to creamish grey thallus, flexuose, stellate or short and circular lirellae, often with thin, lateral thalline intrusions, a black to grey pruinose, prominent disc, 0.3-0.5 mm wide, and brown, consistently 6-locular spores, 22-38 x 10-12 µm (see Hayward 1977 for full description). In Tasmanian specimens, the hymenium is 80-90 µm thick and the thallus contains no substances detectable by t.l.c. In contrast, neotropical material has a thicker hymenium, 6-8 locular spores and includes specimens which contain unidentified lichen acids (Wirth & Hale 1978).

Selected specimens examined: Scotts Peak Road, on *Eucryphia lucida* at edge of rainforest, 350 m, 26.ix.1980, *Kantvilas* 434/80 (HO, BM). Mt Victoria Track, on *Pittosporum bicolor*, 840 m, 8.xii.1981, *Kantvilas* 1111/81 (HO, BM). Sumac Road, Spur 2, south of Arthur River, on *Nothofagus cunninghamii*, 170 m, 14.v.1981, *Kantvilas* 324/81 (HO, BM).

19. ***Phlyctis subuncinata*** Stirton

J. Linn. Soc. Lond. Bot. 14: 464 (1875); type: New Zealand, Wellington, *J. Buchanan* 145 (BM! - lectotype [*fide* Galloway 1983]).

Phlyctis subuncinata is common and widespread in Tasmanian rainforests and wet sclerophyll forests where it occurs on shaded trunks with smooth bark, particularly *Atherosperma moschatum* and *Pomaderris apetala*. It is a pioneer species and is usually associated with *Thelotrema lepadinum*, *Bacidia weymouthii*, *Catillaria tasmanica*, *Sarrameana tasmanica* and other crustose lichens. The species is recognised by small, ± irregular, fleck-like, white sorediate-leprose patches which mark the position of immersed, usually clustered apothecia. Spores are hyaline, fusiform, 7-septate, 40-53 x 4.5-7 µm. A full description is provided by Galloway (1985). Tasmanian specimens contain stictic and cryptostictic acids (medulla and soredia K+ yellow, PD+ orange) but Galloway (1985) also records norstictic acid in specimens from New Zealand.

Selected specimens examined: Corinna, on *Pomaderris apetala* in wet sclerophyll forest, 80 m, 10.ii.1982, *Kantvilas* 286/82 (HO). Little Fisher River, on *Atherosperma moschatum* in rainforest, 950 m, 18.iii.1982, *Kantvilas* 285/82 (HO). Styx River, on *Atherosperma moschatum* in rainforest, 370 m, 27.xi.1981, *Kantvilas* 1050/81 (HO, BM).

20. *Porina leptalea* (Durieu & Mont.) A.L. Smith

Monogr. Brit. Lich. 2: 333 (1911).- *Biatora leptalea* Durieu & Mont., *Fl. d'Alger., Crypt.* 1: 268 (1846-1849).

Porina leptalea is characterised by an effuse, grey-green, very thin thallus, reddish-brown, hemispherical perithecia, *c.* 0.15-0.25 mm wide, simple paraphyses, and hyaline, fusiform, 3-septate spores with acute apices, 15-23 x 3-5 µm (see Swinscow 1962). It is an occasional, very inconspicuous and easily overlooked species in Tasmanian rainforest, found in locally dry, corticolous habitats including old, decorticating trunks and the undersides of canopy twigs and branches. Associated taxa include *Scoliciosporum pruinosum* and *Opegrapha viridis*. *Porina leptalea* is also known from Europe and the British Isles (Swinscow 1962).

P. leptalea is one of three superficially similar taxa with reddish brown perithecia, all of which occur in similar habitats, mostly allopatrically. It differs from its closest relative, *P. leptaleina*, by the smaller perithecia and spores (see below). The third species remains undetermined but is closely related to *P. nucula* Ach. (*sensu* Swinscow 1962) and *P. heterospora* (Fink) R.C. Harris (see Tucker & Harris 1980) (P. McCarthy *pers. comm.*). It has large fusiform spores 32-80 x 6-12 µm with 7-12 septa and only a few algal cells imbedded in a thick involucrellum.

Specimens examined: Yarlington Tier, on undersides of *Nothofagus cunninghamii* twigs, 620 m, 8.xi.1987, *Kantvilas* 89/87 (HO). Simons Road near Ben Nevis, on *Nothofagus cunninghamii*, 830 m, 7.xii.1981, *Kantvilas* 1185/81 (HO). Balts Spur, Tasman Peninsula, on undersides of *Nothofagus cunninghamii* twigs, 420 m, vii.1983, *Kantvilas* 150/83 (HO). Little Fisher River, on old dry trunk of *Nothofagus cunninghamii*, 880 m, 15.ii.1984, *Kantvilas & James* 431/84 (HO, BM)

21. *Porina leptaleina* (Nyl.) Müll. Arg.

Bull. Herb. Boissier 2, *App.* 1: 91 (1894). - *Verrucaria leptaleina* Nyl., *Lich. Nov. Zel.*: 130 (1888).

Porina leptaleina is very similar to *P. leptalea* (above), differing from that species by its marginally larger perithecia (*c.* 0.2-0.0.4 mm diam.) and larger, 3-septate, fusiform spores, 21.5 - 30 (-34) x 3.5 - 6 µm (see also Galloway 1985: 415). It occurs in locally dry, corticolous habitats, identical to those where *P. leptalea* grows. *P. leptaleina* is also known from New Zealand.

Selected specimens examined: Weindorfers Forest, on undersides of *Nothofagus cunninghamii* twigs, 920 m, 9.ii.1988, *Kantvilas* 24/88, (HO). Anthony Road, on twigs of *Atherosperma moschatum* in rainforest, 560 m, 16.xii.1988, *Kantvilas* 564/88 (HO). Mt Sprent, on *Epacris serpyllifolia* twigs, 850 m, 5.ii.1987, *Kantvilas* 130/87 *pp.* (HO). Approximately 3 km south of Teepookana, on twigs of *Lagarostrobos franklinii*, 220 m, 7.xi.1990, *Kantvilas* 620/90 (HO).

22. *Scoliciosporum pruinosum* (P. James) Vězda

Folia geobot. phytotax. 13: 414 (1978). - *Bacidia pruinosa* P. James, *Lichenologist* 5: 117 (1971); type: Great Britain, V.C.II, South Hants, New Forest, Brockenhurst Whitley Wood, 24.xi.1968, *F. Rose* (BM! - holotype).

This species is recognised by its granular, ecorticate whitish grey thallus, immarginate, almost subglobose, whitish to very pale pink apothecia and hyaline, filiform, sigmoid, indistinctly 3-5 septate spores, 24-34 x 1-2 µm. A full description with illustrations is provided by James (1971). Previously known only from Europe, *S. pruinosum* is found in rain-sheltered microhabitats in Tasmanian rainforest, particularly on the undersides of smooth-barked canopy twigs of *Nothofagus cunninghamii*. Associated lichens include *Porina leptaleina*, *P. leptalea* and *Opegrapha viridis*. The thallus of Tasmanian specimens reacts K-, C-, PD-, KC+ pink, UV+ white and contains traces of gyrophoric acid.

Selected specimens examined: Little Fisher River, on *Nothofagus cunninghamii*, 820 m, 9.vi.1982, *Kantvilas* 188/82 (HO, BM). Yarlington Tier, on dead dry trunk of *Nothofagus cunninghamii*, 620 m, 28.x.1987, *Kantvilas* 86/87 (HO, herb. Vězda). Balt Spur, on canopy twigs of *Nothofagus cunninghamii*, 420 m, vii.1983, *Kantvilas* 145/83 (HO, herb. Vězda).

23. *Thelotrema decorticans* Müll. Arg.

Bull. Herb. Boissier 1: 54 (1893); type: Victoria, Black Spur, 1888, *F. R. M. Wilson* 514 (G! - holotype; MEL! - isotype).

Thelotrema decorticans is widespread in Tasmania in scrub, wet sclerophyll forest and rainforest where it occurs amongst bryophytes or on fibrous bark, usually on shaded trunk butts. It has distinctive, *Geaster*-like apothecia, 0.5-1 mm diameter, with thick, cracked, exfoliating margins which obscure the disc except for a central pore. Morphologically, the species is indistinguishable from *T. subdenticulatum* (see below) but is recognised by its characteristic spores. These are 8 per ascus, muriform, with *c.* 10-14 transverse and (0-)1-3 longitudinal septa, fusiform to broadly ellipsoid, 35-60 x 11-19 µm. A full description is provided by Galloway (1985: 573). *T. decorticans* is also known from New Zealand and mainland Australia.

Selected specimens examined: Lake Highway near Projection Bluff, on *Nothofagus cunninghamii*, 980 m, 17.iii.1982, *Kantvilas* 80/82 (HO, herb. Vězda). Flannel Road, near Arthur River, on *Notelaea ligustrina*, 360 m, 19.i.1982, *Kantvilas* 288/82 (HO, herb. Vězda). Little Rapid River, on *Eucalyptus nitida*, 230 m, 19.ii.1982, *Kantvilas* 51/82 (HO, herb. Vězda, BM). Hellyer Gorge, on *Nothofagus cunninghamii*, 26.ix.1986, *Kantvilas* 175/86 (HO, BM). Olga River at Line 7, on *Leptospermum lanigerum* in wet scrub, 70 m, 31.iii.1990, *Kantvilas* 173/90 (HO, GZU).

24. *Thelotrema subdenticulatum* (Zahlbr.) G.Salisb.

Lichenologist 5: 267 (1972). - *Ocellularia subdenticulata* Zahlbr. in Skottsberg, *Nat. Hist. Juan Fernandez* 2: 329, Tab. 24, fig. 6 (1924).

Thelotrema subdenticulatum is morphologically indistinguishable from *T. decorticans* (see above), but can be recognised by its spores which are 8 per ascus, 59-120 x 8-18 μm, with 16-26 transverse septa. The species is also known from Juan Fernandez and New Zealand (Salisbury 1972, 1975). It is widespread and common in Tasmanian rainforest and occurs either over bryophytes or directly on wood, usually in deep shade. It is also common at forest margins or in wet scrub on the fibrous bark of *Eucalyptus*, *Leptospermum* and *Melaleuca*.

Selected specimens examined: South of Meunna, on *Nothofagus cunninghamii*, 370 m, 16.ii.1982, *Kantvilas* 272/82 (HO, herb. Vězda). Near Nelson Bay River, on *Eucalyptus nitida*, 140 m, 6.iv.1984, *Kantvilas* 629/84 (HO, BM). Tarraleah, on *Nothofagus cunninghamii*, 600 m, 27.iv.1982, *Kantvilas* 129/82 (HO, herb. Vězda). Granville Harbour, on *Melaleuca squarrosa*, 20 m, 7.ii.1984, *Kantvilas & James* 237/84 (HO, BM).

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REVISIONS AND ADDITIONS TO THE DIAPORTHALES

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Barr (1990) proposed a revised classification of the genera belonging to this order into three families rather than four (Barr 1978) or two (Cannon 1988). The ascospores are of primary importance in separating genera into the Gnomoniaceae (thin walled, hyaline, amero-, apio-, didymo- or scolecosporous), Valsaceae (thin walled, hyaline, allantoid or oblong, amerosporous), and Melanconidaceae (firm walled, hyaline or pigmented, amero-, didymo-, phragmo- or dictyosporous). The combinations of absence or presence and type of stromatic tissues, configuration of ascomata, and ascospore characters delimit the genera. Some changes in nomenclature and newly uncovered taxa are noted below under the families Gnomoniaceae and Melanconidaceae. The Valsaceae has no additions in this revision. I recommend Spielman's (1985) revision of species in *Valsa* that develop in woody angiosperms.

Gnomoniaceae

Apiognomonia. Monod (1983) enlarged the genus to include several species that have a nonmedian ascospore septum, but that are not truly apiosporous, i.e., with smaller cell one-third or less of length. Two of these, *A. ostryae and A. rigniacensis*, are known from North America as well as Europe; they are both returned to *Gnomonia*. *Apiognomonia errabunda* (Roberge in Desm.) v. Höhnel is retained in the narrow sense of Barr (1978), although Monod had included in his concept of the species *A. quercina* (Klebahn) v. Hőhnel, *A. tiliae* (Klebahn) v. Höhnel, and *A. tiliae var. magnoliae* Barr. Monod raised *A. alniella* (Karsten) v. Höhnel var. *ribis* Barr to species rank, with which I concur, thus *A. ribis* (Barr) Monod. In the same manner and for the same reasoning I propose *A. magnoliae* (Barr) Barr, comb. nov. (basionym: *A. tiliae var. magnoliae* Barr, Mycol. Mem. 7: 28. 1978). Species in *Gnomonia* section Clava, e.g., *G. clavulata and G. myricae* may have the ascospore septum submedian but not truly apiosporous, and are retained in *Gnomonia*.

The North American species are separable by ascospore shape -- fusoid with acute ends or obovoid with obtuse ends (apically at least) -- and relative width, in addition to ascoma sizes and host plant.

Key to North America Species of *Apiognomonia*

1. Ascospores fusoid, ends acute; ascomata small or medium sized, beaks short or elongate............................2
1. Ascospores obovoid, ends obtuse; ascomata medium sized, beaks elongate.....................................6
2. Ascomata medium sized, beaks short and wide......3
2. Ascomata small, beaks short or elongate, narrow..4
3. Ascospores 15-17 x 3.5-4 µm; on *Fagus*......*A. errabunda*
3. Ascospores (12-)14-20 x 3-5(-7) µm; on *Platanus*...*A. veneta*
4. Beaks short; ascospores 10-15(-20) x 3-4(-6) µm...*A. quercina*
4. Beaks elongate.................................5
5. Ascospores 12.5-17.5 x 3.5-5.5 µm............*A. tiliae*
5. Ascospores 11-15 x 3-4.5 µm................*A. magnoliae*
6. Ascospores 10-16 x 3.5-5.5 µm..........*A. alniella*
6. Ascospores 10.5-13.5 x 4-6 µm............*A. ribis*

Apioporthella was described for *A. bavarica* Petrak on *Alnus viridis* (Chaix) DC. and is not yet known in North America. *Diaporthe apiospora* Ellis & Everh. on *Ulmus* seems to be closely related. It was described from Ontario and is known from Iowa also [Wehmeyer 1933 as *Apioporthe apiospora* (Ellis & Everh.) Wehm.]. A collection from Massachusetts (Franklin Co., Conway, Baptist Hill, 30 Dec 1979, *Ulmus americana*, M. E. Barr 6655, NY) extends the known range of the fungus. The ascomata are valsoid in configuration beneath a slight stromatic disc (Fig. 1); ascospores are 12-15 x 5-6 µm, oblong obovoid, apiosporous, the lower cell ca. 3.5-5 µm long by 3-3.5 µm wide, with short pulvinate appendages (Fig. 2). The combination *Apioporthella apiospora* (Ellis & Everh.) Barr, comb. nov. is proposed (basionym: *Diaporthe apiospora* Ellis & Everh. Proc. Acad. Nat. Sci. Philadelphia 45: 140. 1893). The taxon usually determined as *Cryptodiaporthe vepris* (De Lacr.) Petrak in canes of *Rubus* (and known from *Sambucus* also) fits well as a species of *Apioporthella*. The ascospores differ in smaller sizes (6.5-11 x 1.5-2.5 µm) and narrow setose appendages 2-3.5 µm long. The combination *Apioporthella vepris* (De Lacr.) Barr, comb. nov. is also proposed (basionym: *Sphaeria vepris* De Lacr. in Rabenh. F. Eur. 443. 1859). Monod (1983) obtained an anamorph having hyaline, one celled conidia 4.5-6 x 1.5 µm in culture; at low temperature ascomata formed. The name *Apiothecium* (Vasilyeva 1987) for *A. vepris* is an unnecessary one.

Clypeoporthe was reduced to synonymy under *Gnomonia* by Monod (1983), but the genus seems quite separable for species whose ascomata develop in eutypelloid configuration in prosenchymatous stromatic tissues. The known species are in culms of large grasses.

Cryphonectria. The concept of species has benefitted from recent studies, noted below. Three subtropical and tropical species are *C. coccolobi* (Vizioli) Micales & Stipes (Micales and Stipes 1986), *C. cubensis* (Bruner) C. S. Hodges (Hodges et al. 1986, Micales et al. 1987), and *C. havanensis* (Bruner) Barr (Hodges 1980, Walker et al. 1985), which is difficult to separate from *C. gyrosa* (Berk. & Broome) Sacc. Two temperate-zone species are *C. parasitica* (Murrill) Barr, chiefly infecting *Castanea*, and *C. radicalis* (Schwein.: Fr.) Barr on *Castanea* and *Quercus*.

Cryptodiaporthe. Monod (1983) transferred *Ditopellopsis racemula* (Cooke & Peck) Barr to this genus, but the presence of a pseudoparenchymatous stroma requires that the species be retained in *Ditopellopsis*. He arranged *C. petiolophila* in *Gnomonia*; in this species a few ascomata are typically grouped in valsoid configuration beneath a prosenchymatous stromatic disc. *Cryptodiaporthe petiolophila* (Peck) Barr develops in leaf blades and petioles of *Acer*. *Cryptodiaporthe densissima var. spicata* (Ellis & Everh.) Wehm. is close to *C. petiolophila* but occurs in thin branches rather than petioles and has somewhat longer ascospores. It appears best placed as *C. petiolophila var. spicata* (Ellis & Everh.) Barr, comb. nov. (basionym: *Diaporthe spicata* Ellis & Everh. Proc. Acad. Nat. Sci. Philadelphia 45: 143. 1893). [*Cryptodiaporte densissima* (Ellis) Wehm. is a synonym of *Amphiporthe raveneliana* (Thümen & Rehm) Barr according to Barr 1978]. *Cryptodiaporthe hystrix* (Tode: Fr.) Petrak is known in North America endophytic in *Acer macrophyllum* Pursh (Sieber et al. 1990). This species differs from *C. petiolophila* and var. *spicata* by longer ascospores and by widely erumpent, quite flattened beaks.

Cryptodiaporthe aubertii (West.) Wehm. var. *comptoniae* (Schwein.) Wehm. should be accepted as a separate species, *C. comptoniae* (Schwein.) Barr, comb. nov. (basionym: *Sphaeria comptoniae* Schwein, Trans. Amer. Philos. Soc. n.s.4: 201, n. 1353. 1832). This species has an anamorph, *Uniseta flagellifera* (Ellis & Everh.) Ciccarone (Wehmeyer 1933). This anamorph was described and illustrated by Nag Raj (1974) and is distinctive by the light brown, one-septate conidia that have a terminal elongate appendage. A collection on *Vaccinium angustifolium* Aiton (Michigan: Cheyboygan Co., Topinabee Oaks, 19 Jul 1953, M. E. Barr 999, NY) has conidiomata intimately connected to ascomata and also agrees in teleomorph characteristics with *C. comptoniae*.

A species on *Goodyera* does not fit in any of the described species of *Cryptodiaporthe*, nor is there a record of the genus on any of the Orchidaceae. This species is close to *C. acerinum* Reid & Cain in ascomata and ascospores, but the ascospore wall is smooth. Kobayashi (1970) illustrated that species with old conidial locules in the stroma, and similar locules are present in the fungus described below.

Cryptodiaporthe goodyerae Barr & Rogerson, sp. nov.
Figs. 3-5

Stromata immersa exigua brunnea, ascomata 440 µm lata 330 µm alta, rostra vel 330 µm. Asci unitunicati 60-72 x 12-15 µm, annuli vadosi, aparaphysati. Ascosporae 15-20 x 5-6.5 µm hyalinae oblongae ellipsoideae uniseptatae biseriatae. Anamorphus in stromate loculatus; conidia 13-16 x 7.5-8 µm aut 20-27 x 5-7 µm hyalina ellipsoidea uniseptata. Holotypus in pedunculis *Goodyerae oblongifoliae* Raf., "Utah: Weber Co., Wasatch Mts. E of Ogden, trail to Malan's Peak from Taylor Canyon, ca. 6000 ft, 20 Jul 1983," a C. T. Rogerson lectus, in NY depositus.

Stromatic tissues slight, brown, prosenchymatous; ascomata few (2-5), ca. 440 µm wide, 330 µm high; beaks up to 330 µm long; peridium narrow. Asci 60-72 x 12-15 µm, apical ring refractive. Ascospores 15-20 x 5-6.5 µm, hyaline, oblong ellipsoid, ends obtuse, 1-septate, nearly median, slightly constricted; wall smooth. Anamorph (*Diplodina*) forming locules in same stromata; conidiogenous cells short, enteroblastic-phialidic; conidia of two sizes: 13-16 x 7.5-8 µm and 20-27 x 5-7 µm, hyaline, ellipsoid, one septate.

Known only from the holotype collection.

Species of *Cryptodiaporthe* may be recognized by ascospore shape and size in conjunction with substrate, for the majority are host specific.

Key to North American Species of *Cryptodiaporthe*

1. Ascospores narrow, 1-3.5 µm wide......................2
1. Ascospores wider, (3-)4-7(-8) µm wide................6
    2. Ascospores 14.5-23 x 2-3.5 µm...................3
    2. Ascospores mostly shorter, 7-17 µm long.........4
3. Beaks short erumpent, cylindric; in *Salix*..*C. apiculata*
3. Beaks long erumpent, flattened; in *Acer*......*C. hystrix*
    4. Ascospores 7.5-10 x 1.5-2.5 µm; in *Spiraea*........ ....*C. macounii*
    4. Ascospores ranging longer; in *Acer*...............5
5. Ascospores 7-12(-14) x 1-2.5 µm, in petioles........... ....*C. petiolophila* var. *petiolophila*
5. Ascospores 12-17 x 2.5-3 µm; in twigs.................. ....*C. petiolophila* var. *spicata*
    6. Ascospores 8-12(-16.5) µm long...................7
    6. Ascospores (11-)12-26 µm long....................8

7. Ascospores 8-11 x 3-4 µm, straight; in *Myrica*..........
....*C. phomaspora*

7. Ascospores 9-12(-16.5) x 3.5-5 µm, usually curved or bent at septum; in *Comptonia & Vaccinium*.....*C. comptoniae*

   8. Ascospores 18-26 x 4-5.5 µm; in *Fagus*............
   ....*C. galericulata*

   8. Ascospores (11-)12-20 µm long; in other substrates
  9

9. Ectostromatic disc bright orange; ascospores 12-17.5 x 5-7 µm, septum usually submedian; in *Cornus alternifolia*...*C. corni*

9. Ectostromatic disc pallid, yellowish or brownish; ascospore septum nearly median...........................10

   10. Ascospores 13-16.5(-20) x 3.5-5 µm; in *Myrica*....
   ....*C. aubertii*

   10. Ascospores wider, (4-)5-8 µm...................11

11. Ectostromatic disc brownish to blackish; ascospores 13-18 x 6-7 µm, wall verruculose; in *Acer*......*C. acerinum*

11. Ectostromatic disc pallid or yellowish; ascospore wall smooth; in other substrates...........................12

   12. In Orchidaceae; ascospores 15-20 x 5-6.5 µm......
   ....*C. goodyerae*

   12. In Salicaceae................................13

13. Ascospores (11-)13-20 x (4-)5-6.5 µm......*C. salicella*

13. Ascospores 14-20 x 6-8 µm...................*C. populea*

Ditopellopsis was not accepted by Monod (1983), who argued that in *D. clethrae* Reid & Booth the stromatic coating is in fact only perithecial wall, and proposed *Gnomonia clethrae* (Reid & Booth) Monod for this species. He also preferred to retain *D. alni* (Thompson & Miller) Barr under *Mamiania*, despite the differences in ascospores, and to assign *D. racemula* (Cooke & Peck) Barr as *Cryptodiaporthe racemula* (Cooke & Peck) Monod. Because of the well-defined pseudoparenchymatous stroma that surrounds one or a few ascomata, *Ditopellopsis* is retained as a separate genus for these three species.

Gaeumannomyces. Three species were discussed in detail by Walker (1980). The heterothallic *G. incrustans* Landschoot & Jackson was recently added to the genus (Landschoot and Jackson 1989).

Gnomonia. Understanding of species has been greatly facilitated by Monod (1983), who studied a number of European type collections and clarified their concepts. He found that some North American entities were dissimilar to their European counterparts. The changes accepted, and a few additional taxa, are incorporated below in the sequence of sections and species utilized by Barr (1978). A revised key to species is provided.

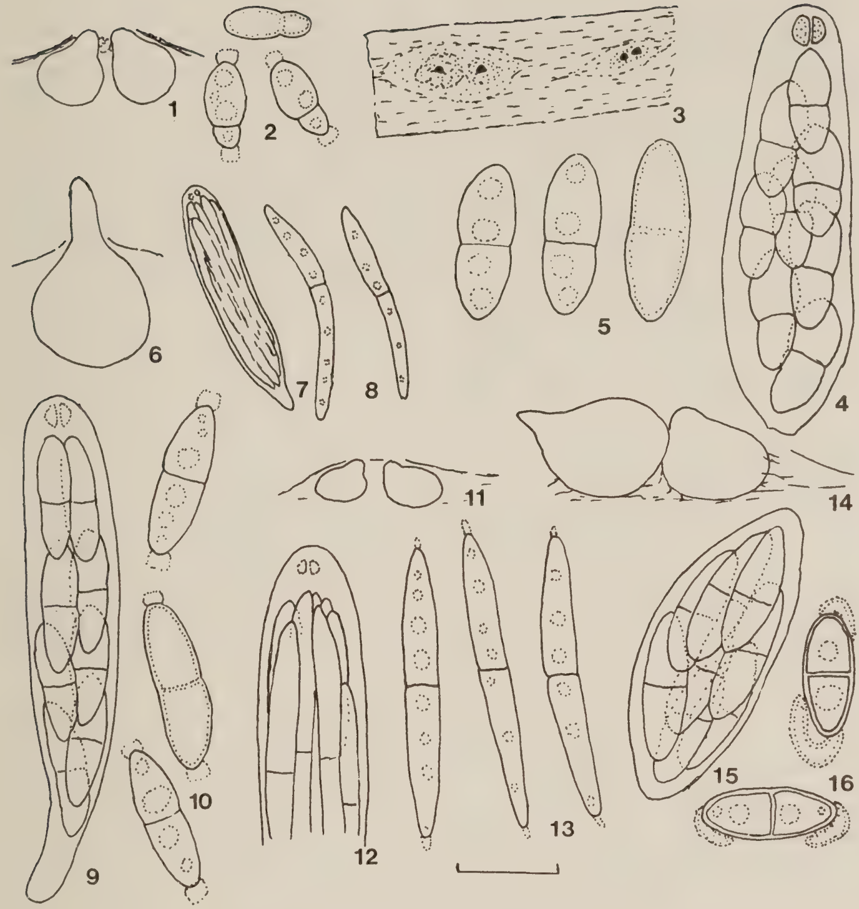
Section Gnomonia: *Gnomonia gnomon* (Tode: Fr.) Schröter is known from North America in Ontario whereas *Gnomonia* *ostryae* de Not. [as *Apiognomonia ostryae* (deNot.) Monod] includes specimens listed under *G. gnomon* from Wisconsin, Georgia and California, as well as other collections. *Gnomonia californica* Monod is separated from *G. amoena* (Nees: Fr.) Ces. & de Not. for the collections from Oregon listed under that European epithet in Barr (1978). *Gnomonia rigniacensis* Sacc. & Flag. was transferred as *Apiognomonia rigniacensis* (Sacc. & Flag.) Monod. I prefer to retain the species in *Gnomonia* for while the ascospores have a supramedian septum, they are not truly apiosporous.

Section Seta: Monod (1983) separated the closely related species *G. setacea* (Pers.: Fr.) Ces. & de Not. on *Quercus* and *Castanea* from *G. nervisequa* (Wallr.) Fuckel, on members of the Betulaceae. Both species have similarly sized ascomata, long narrow beaks, small asci, and differ in ascospore size ranges and substrates. The complex *G. nerviseda* Cole (Barr 1978) was separated as three species by Monod (1983): *G. caryae* Wolf, including *G. setacea var. macrospora* Ellis & Everh. and *G. setacea var. caryae* Dearness & House, with long ascospores; *G. pecanae* (Cole) Monod with narrower, intermediately long ascospores; *G. nerviseda* Cole with shorter ascospores.

Section Cylindrica: *Gnomonia caryae var. ribis* Barr differs from *G. caryae* in larger ascomata with longer beaks, slightly wider ascospores, and substrate. The combination *G. ribis* (Barr) Barr (basionym: *Gnomonia caryae var. ribis* Barr, Mycol. Mem. 7: 46. 1978) is proposed for this taxon. *Gnomonia aesculi* Oudemans proved to be a synonym of *G. cerastis* (Riess) Ces. & de Not. and Monod (1983) proposed *G. milleri* Monod for the Georgia collection described as *G. aesculi* by Barr (1978). *Gnomonia fasciculata* Fuckel was included as a synonym of *G. setacea* (Pers.: Fr.) Ces. & de Not. by Monod (1983) and the collections on *Quercus* from northeastern North America are assigned there. The specimens from Utah and Arizona on *Quercus gambellii* Nutt. were separated as *G. quercus-gambellii* Monod, with Barr 6095 designated as holotype. The type of *G. lirellaeformis* Pass. provided no species of that genus and the fungus described as *Pleuroceras lirellaeformis* (Pass.) Barr on *Quercus rubra* L. var. *borealis* (F. Michx) Farw. from northeastern North America has beaks that may be central or approaching lateral, ascospores that although elongate may be accommodated in *Gnomonia as G. quercus-borealis* Monod. The Californian material on *Quercus agrifolia* Née differs from *G. quercus-borealis* in small ascomata with short beaks and more elongate ascospores.

Gnomonia agrifoliae Barr, sp. nov. Figs. 6-8

Ascomata immersa 140-200 µm lata vel 100 µm alta, rostra media vel excentrica 78-125 µm alta 35-50 µm lata. Asci unitunicati 40-55 x 5-10 µm, annuli vadosi,



Figs. 1-2. Apioporthella apiospora: 1, habit of ascomata; 2, ascospores. 3-5. *Cryptodiaporthe goodyerae*: 3, habit, surface view of ascomata and conidial locules; 4, ascus; 5, ascospores. 6-8. *Gnomonia agrifoliae*: 6, outline of ascoma; 7, ascus; 8, ascospores. 9-10. *Plagiostoma jensenii*: 9, ascus; 10, ascospores. 11-13. *Pleuroceras virgularum*: 11, habit of ascomata; 12, upper part of ascus; 13, ascospores. 14-16. *Plagiophiale ligulata*: 14, outline of ascomata; 15, ascus; 16, ascospores. Standard line = 15 um for ascus and ascospore drawings, 150 um for figs. 6, 14. Habit sketches not to scale.

aparaphysati. Ascosporae 25-35 x 2-3 µm hyalinae elongatae cylindricae uniseptatae fasciculatae. Holotypus in foliis *Querci agrifoliae*, "California: Marin Co., Alpine Lake, Mt. Tamalpais, 2 Dec 1971," a M. E. Barr 5912b lectus, in NY depositus.

Ascomata immersed, 140-200 µm wide, up to 100 µm high; beaks central or eccentric, 78-125 µm high, 35-50 µm wide near base, tapered to apex; peridium narrow, 10-12 µm wide. Asci 40-55 x 5-10 µm, apical ring small, refractive. Ascospores 25-35 x 2-3 µm, hyaline, elongate cylindric or wider above, tapered to obtuse ends, 1-septate median; wall smooth, two or three globules per cell; in fascicle in the ascus.

In leaves of *Quercus agrifolia*. California: Alpine Lake, Mt. Tamalpais, Marin Co., 2 Dec 1971, M. E. Barr 5912b (NY, holotype, as *Pleuroceras lirellaeformis*); vicinity of Berkeley, Dec 1989, M. Taper (NY, isotype).

Section Latispora: *Gnomonia intermedia var. alni* Barr is predated by *Gnomonia alni-viridis* Podlahova & Svrček as Monod (1983) determined. *Unlike Plagiostoma alneum* (Fr.) von Arx, var. *betulinum* Barr has nearly central beaks and is identical with *Gnomonia betulina* Vleugel (Monod 1983). It fits in section Latispora as a large-spored species whose appendages are pulvinate. *Gnomonia rubi* (Rehm) Winter is a synonym of *G. rostellata* (Fr.) Wehmeyer. Asci contain four ascospores, or eight of which four are normal and four degenerated.

Section Clava: *Gnomonia gei-montani* Ranojevic has ascospores with a submedian septum, 10-13 x 2-2.5 µm, and is European according to Monod (1983). The entity under that name in Barr is now *G. peckii* Monod, with ascospores having a nearly median septum, and smaller, 8-11 x 1.5-2 µm. *Gnomonia misella* Niessl is treated as a synonym of *G. riparia* Niessl. Both names were published in the same article, *G. riparia* on p. 47, *G. misella* on p. 48.

Because many species of *Gnomonia* have a restricted host range, it is helpful to utilize substrate for separation of species in some cases. This is particularly valuable for species on *Carya*, *Quercus*, and Betulaceae, where several species are known.

Key to North American Species of *Gnomonia*

1. In leaves and petioles of *Carya* spp....................2
1. In other plants..5
    2. Ascospores 13-22.5 µm long, appendages setose....3
    2. Ascospores mostly longer, 19-39 µm, appendages pulvinate or lacking...............................4
3. Ascospores 13-15(-21) x 2-3 µm.............*G. nerviseda*
3. Ascospores 13-22.5 x 1.5-2.5(-3.5) µm........*G. pecanae*

4. Asci 2-spored; ascospores 23-39 x 4.5-9 µm, appendages lacking........................*G. dispora*
4. Asci 8-spored; ascospores 22-37 x 2.5-4(-5.5) µm, appendages pulvinate........................*G. caryae*
5. In leaves of *Quercus (& Castanea)*....................6
5. In leaves of other plants..........................10
6. Ascospores 7.5-10.5 x 3-4 µm, septum submedian..*G. clavulata*
6. Ascospores longer and narrower..................7
7. Ascospores 8-15(-18.5) µm long, appendages setose.....8
7. Ascospores 22-35 µm long, lacking appendages..........9
8. Ascospores 8-15 x 1-2(-2.5) µm..........*G. setacea*
8. Ascospores 11-15 x 2.5-3 µm...*G. quercus-gambellii*
9. Ascospores 22-31 x 1-1.5(-2) µm, septum submedian...*G. quercus-borealis*
9. Ascospores 25-35 x 2-3 µm, septum about median...*G. agrifoliae*
10. In leaves of Betulaceae.......................11
10. In other plants...............................18
11. Ascospores (10-)12-16(-18.5) x 1-2 µm, septum median, appendages setose..........................*G. nervisequa*
11. Ascospores longer or wider or septum supramedian....12
12. In leaves of *Alnus*..........................13
12. In other plants...............................14
13. Ascospores 9-12 x 2-4 µm, appendages setose; asci 8-spored...................................*G. alni-viridis*
13. Ascospores 15-27 x 3-4.5 µm, lacking appendages; asci usually 4-spored................................*G. alni*
14. In leaves of *Betula*; ascospores relatively wide ellipsoid.......................................15
14. In leaves of *Corylus*, *Ostrya*; ascospores relatively narrow fusoid, appendages setose.............16
15. Ascospores 9-11(-12) x 2-2.5 µm, lacking appendages...*G. intermedia*
15. Ascospores 20-23 x 4.5-5.5 µm, appendages pulvinate...*G. betulina*
16. Ascospores (10-)12-15 x 1.5-2.5 µm, septum supramedian...................................*G. ostryae*
16. Ascospores 13-25 µm long, septum about median..17
17. Ascospores 13-19.5 x 1.5-2 µm...............*G. coryli*
17. Ascospores 15-25 x 1.5-2.5 µm...........*G. californica*
18. Ascospores narrow, fusoid, l:w ratio 5-6:1 or greater...19
18. Ascospores wide, ellipsoid, l:w ratio 3-4:1....30
19. Beaks erumpent through whitish collar; ascospores 10-16 x 1.5-2 µm, appendages setose; in *Liquidambar*...*G. petiolorum*
19. Beaks not erumpent through collar..................20
20. Ascospores 6.5-15.5 µm long...................21
20. Ascospores 13-30 µm long......................25
21. Asci 4-spored; ascospores 11-16 x 2.5-3.5 µm, appendages setose; in *Oenothera*....................*G. riparia*
21. Asci 8-spored......................................22
22. Ascospores 2-3 µm wide, appendages lacking.....23

22. Ascospores 1.5-2 µm wide........................24

23. Ascospores 6.5-12 µm long, septum submedian; in Rosaceae.......................................*G. comari*

23. Ascospores 13.5-15 µm long, septum median..*G. triostei*

24. Ascospores 7.5-10.5 µm long, appendages setose; in *Fraxinus*..........................*G. artospora*

24. Ascospores 11-15.5 µm long, appendages lacking; in *Acer*..............................*G. cerastis*

25. Ascospores 13-21 µm long..........................26

25. Ascospores 19-30 µm long..........................28

26. Ascospores 16.5-21 x 3-3.5 µm, appendages setose, septum supramedian; in *Cornus*.........*G. rigniacensis*

26. Ascospores 15.5-20 x 3.5-4 µm, appendages pulvinate or lacking...................................27

27. Ascospores 13-16.5 x 2-3 µm, appendages pulvinate...*G. rhuicola*

27. Ascospores 15.5-20 x 3.5-4 µm, appendages lacking...*G. linnaeae*

28. Ascospores 19-25 x 2.5-3 µm, appendages lacking...*G. juglandis*

28. Ascospores 22-30 µm long, appendages pulvinate.29

29. Ascospores 22-25 x 2.5-3 µm; in *Aesculus*....*G. milleri*

29. Ascospores 26.5-30 x 3-4 µm..................*G. ribis*

30. Ascospores 16-24 x 5-6.5 µm, appendages setose...*G. dryadis*

30. Ascospores shorter, to 16.5 µm long...........31

31. Beaks erumpent through whitish or yellowish collar..32

31. Beaks not erumpent through collar..................34

32. Collar yellowish; ascospores 9-12 x 2.5-4 µm, appendages setose; Bermuda, in *Coccoloba*..*G. pulcherrima*

32. Collar whitish or yellowish; ascospores shorter, 6.5-7.5 µm long..................................33

33. Collar yellowish; ascospores 2-2.5 µm wide, appendages setose septum submedian.....................*G. dalibardae*

33. Collar whitish; ascospores 1.5-2 µm wide, appendages lacking, septum median.....................*G. waldsteiniae*

34. Ascospores 7.5-12 x 2.5-4 µm, appendages lacking, septum submedian.................*G. myricae*

34. Ascospore septum about median, appendages setose...35

35. Ascospores 7-10 x 1.5-2.5 µm; in *Rosa*.........*G. rauii*

35. Ascospores wider, 2-4.5 µm.........................36

36. Asci 4-spored or 8-spored with four abortive; ascospores 10-15.5 x 2.5-3.5 µm; in *Rubus*..*G. rostellata*

36. Asci 8-spored.......................................37

37. Ascospores 9-16.5 x 3-4.5 µm; in *Dryas*...*G. sibbaldiae*

37. Ascospores smaller.................................38

38. Ascospores 9-11 x 2.5-3.5 µm; in *Geum*...*G. peckii*

38. Ascospores ranging larger.........................39

39. Ascospores (6.5-)8.5-13 x 2-4 µm...........*G. ribicola*

39. Ascospores 11-14 x 2.5-3.5 µm; in *Euonymus*, *Aralia*, *Vaccinium*.............................*G. similisetacea*

Gnomoniella. Monod (1983) included *Sphaerognomonia carpinea* (Fr.) Potebnia under *Gnomoniella*. *Sphaerognomonia* is retained, pending results of studies by Reid (personal communication). Monod (1983) also made the transfer *Gnomoniella papillostoma* (Dearness & House) Monod, which on re-examination is the correct disposition of this species. *Gnomoniella fraxini* Redlin & Stack was described recently (Redlin and Stack 1988) and was fully documented with the anamorph *Discula fraxinea* (Peck) Redlin & Stack. A revised key to species of *Gnomoniella* follows.

Key to North American Species of *Gnomoniella*

1. Ascospores fusoid, ends acute........................2
1. Ascospores ellipsoid oblong, ends obtuse.............3
    2. Ascospores 9-13 x 2.5-4(-4.5) µm; in *Spiraea*...*G. papillostoma*
    2. Ascospores 12-16 x 3.5-5.5 µm; in *Cassiope*...*G. hyparctica*
3. Beaks stout, elongate; ascospores 11-15.5 x 6-9 µm; in *Alnus*.......................................*G. tubaeformis*
3. Beaks shorter; ascospores 9-12(-13) µm long...........4
    4. Ascospores 9-12 x (3.5-)4.5-5.5 µm, appendage basal; in *Dryas*.............................*G. vagans*
    4. Ascospores 9-11(-13) x 4-5.5 µm, appendage lacking; in *Fraxinus*.......................*G. fraxini*

Kensinjia Reid & Booth is monotypic for *K. umbrina* (Jenkins) Reid & Booth (1989) on *Rosa*, a segregate from "Cryptosporella" that has ascomata in eutypelloid configuration in a light-colored, pseudoparenchymatous stroma and thin-walled, one-celled ascospores.

Linospora. Monod (1983) restricted the genus to species, in leaves of *Populus* and *Salix*, that have laterally beaked ascomata within stromatic capsules. Several species listed in Barr (1978) are instead species of *Pleuroceras*, whose laterally beaked ascomata lack stromatic tissues, or *Ophiognomonia*, whose centrally beaked ascomata lack stromatic tissues. These are noted below under their respective genera. The British Columbia specimen cited as *L. capreae* (DC.: Fr.) Fuckel (Barr (1978) is closer to *L. salix-reticulatae* Monod, for the ascospores are 2-3 µm wide rather than 1.5 µm, although the host species differ. The only other species presently known in North America is *L. tetraspora* Thompson on *Populus*.

Ophiognomonia. In addition to *O. melanostyla* (DC.:Fr.) Sacc. in North America, *O. sassafras* (Ellis & Everh.) Monod [as *Pleuroceras sassafras* (Ellis & Everh.) Barr in Barr 1978] has ascomata whose beaks are typically central, only occasionally eccentric.

Plagiostoma. Monod reduced *Plagiophiale* to synonymy under *Plagiostoma.* This is not acceptable: a small pseudoparenchymatous stroma surrounds the upper regions of ascomata and the thick-walled ascospores require assignment of the genus to the Melanconidaceae.

Section Plagiostoma: Monod (1983) chose to lectotypify the genus by *P. devexum* (Desm.) Fuckel rather than *P. euphorbiae* (Fuckel) Fuckel, for his study of type material of the latter showed that the short beak could be central to lateral but was not inserted on the side. *Plagiostoma devexum* is known from North America as well as from Europe and is a smaller species than *P. euphorbiae. Plagiostoma solidaginis* Cooke & Barr (Cooke and Barr 1983) has been added to the genus as a large-spored species.

Section Guignardia: *Plagiostoma alneum var. betulinum* Barr is a synonym of *Gnomonia betulina* Vleugel, as Monod indicated and as accepted above. *Plagiostoma bavaricum* (Rehm) Barr is European in leaves of *Acer pseudoplatanus* L. whereas the North American collection in *A. saccharum* Marsh. under that name in Barr (1978) is *P. pseudobavaricum* Monod, a species with smaller asci and ascospores. Some collections in leaf blades and petioles of *Alnus rubra* Bong. from Oregon and British Columbia are similar to *P. alneum* in ascomata but have considerably larger asci and ascospores. These were brought to my attention by the late Jon Jensen, in whose honor the species is named.

Plagiostoma jensenii Barr, sp. nov. Figs. 9-10

Ascomata immersa, 190-300 μm lata 190-220 μm alta, sine rostro, ostiola lateralia. Asci unitunicati 65-84 x 12-18 μm, annuli 5 x 4-5 μm. Ascosporae 20-30 x 4-6 μm hyalinae ellipsoideae uniseptatae, appendiculae pulvinatae 2-4 μm, biseriatae. Holotypus in foliis *Alni rubrae,* "British Columbia, Vancouver Island, Duncan, 17 Jun 1971," lectus M. E. Barr 5775, in NY depositum sub *P. alneum.*

Ascomata immersed, 190-300 μm wide, 190-220 μm high; beak not formed, ostiole lateral. Asci 65-84 x 12-18 μm, apical ring conspicuous, 5 μm high, 4-5 μm wide. Ascospores 20-30 x 4-6 μm, hyaline, ellipsoid, one septate median; wall smooth, appendages pulvinate, 2-4 μm wide; two or three globules per cell.

In leaves of *Alnus rubra.* British Columbia: Vancouver Island, Duncan, 17 Jun 1971, M. E. Barr 5775 (NY as *P. alneum*, holotype). Oregon: Mary's Peak, Benton Co., 4 May 1983 (NY).

Section Angustisporae: For P. campylostylum sensu Barr, Monod argued that because Auerswald did not cite a holotype and his collections showed two different species, described later as *G. emarginata* Fuckel and *G. betulina* Vleugel, that *G. campylostyla* should be considered a nomen confusum. He further described beaks as central to lateral and retained this species as *Gnomonia emarginata* for European collections having ascospores 17-25 x 2-3 µm in asci 35-48 x 7-11 µm. The North American collections on *Betula* cited by Barr under *P. campylostylum and var. mirabile* all have lateral beaks; their ascospores range 18-27-37 x 2.5-3.5 µm, with short straplike appendages, in asci 50-78 x 10-13.5 µm. Monod grouped these collections as *Gnomonia mirabilis* (Peck) Monod, for he considered *G. emarginata and G. mirabilis* closely related by morphological characters, separating the latter by lateral position of beak, larger asci and ascospores and geographical distribution. I am able to accept the argument in part, but must retain the North American collections as *Plagiostoma mirabile* (Peck) Barr comb. nov. (basionym: *Sphaeria mirabilis* Peck, Rep. New York State Mus. 28 for 1874: 80. "1875" [1876]). The ascospores are narrower than in *Plagiostoma micromegalum* (Ellis & Everh.) Barr, but have similar appendages.

Key to North American Species of *Plagiostoma*

1. Ascospores 6-12 µm long................................2
1. Ascospores (10-)15 µm or longer.......................5
  2. Ascospores fusoid, tapered to acute ends, lacking appendages, septum median..........................3
  2. Ascospores ellipsoid, tapered to obtuse ends, appendages present, septum median or submedian......4
3. Ascospores 8-10 x 2-3 µm: in *Polygonum*, *Rumex*.......... ....*P. devexum*
3. Ascospores 9-11 x 3-4 µm; in *Hudsonia*......*P. conradii*
  4. Ascospores 6-10 x 1.5-3 µm, appendages narrow, septum submedian; in *Potentilla*.......*P. tormentillae*
  4. Ascospores 8-12 x 2-2.5 µm, appendages wide, septum median; in *Acer*............*P. pseudobavaricum*
5. Ascospores narrow, l:w ratio 7-10:1..................6
5. Ascospores wider, l:w ratio 3.5-5:1..................7
  6. Ascospores 18-37.5 x 2.5-4 µm, appendages straplike; in *Betula*.........................*P. mirabile*
  6. Ascospores (15.5-)18-26(-32) x (1-)2-2.5(-3) µm; appendages setose.......................*P. magnoliae*
7. Ascospores with obtuse ends, appendages pulvinate.....8
7. Ascospores with more acute ends, appendages setose or lacking...10
  8. Ascospores 26-36 x 5.5-10 µm; in *Carya*........... ....*P. micromegalum*
  8. Ascospores smaller; in *Alnus*.....................9
9. Ascospores (10-)15-20 x 3.5-5 µm.............*P. alneum*
9. Ascospores 20-30 x 4-6 µm..................*P. jensenii*
  10. Ascospores 15.5-26(-33) x 4-5.5(-6.5) µm, appendages setose, septum submedian.........*P. acerophilum*
  10. Ascospores wider, appendages setose or lacking, septum median.......................................11
11. Ascospores 17-24 x 5.5-7 µm, appendages lacking; in *Potentilla*..................................*P. lugubre*

11. Ascospores (19-)24-28(-32) x 6-8 µm, appendages setose ....*P. solidaginis*

Plagiosphaera is now removed from the Diaporthales to the Lasiosphaeriaceae of Sordariales (Barr 1990).

Pleuroceras. Monod's careful delimitation of this genus, for species with horizontal ascomata lacking stroma, having lateral beaks and elongate fusoid or filiform ascospores, resulted in the reassignment of several species placed in *Linospora* sensu Barr (1978), and the recognition of other North American species.

Pleuroceras pleurostylum (Auersw.) Barr and several other species on *Salix* are European, whereas *P. insulare* (Johans.) Monod, *P. oregonense* Monod, *P. helveticum* (Rehm) Barr and *P. labradorense* Monod are known from North American collections. *Pleuroceras cryptoderis* (Lev.) v. Hohnel is European on *Populus* and *the North American P. populi* Thompson has larger ascospores similarly constricted at the median septum. *Pleuroceras pseudoplatani* (Tubeuf) Monod is European and *P. tenellum* (Ellis & Everh.) Barr is North American in species of *Acer*. *Pleuroceras sassafras* (Ellis & Everh.) Barr seems better accommodated as *Ophiognomonia sassafras* (Ellis & Everh.) Monod, with upright ascomata and central to lateral beaks. *Pleuroceras lirellaeformis* (Pass.) Barr is instead recognized as *Gnomonia quercus-borealis* Monod and *G. agrifoliae* Barr, as noted above. *Plagiosphaera gleditschiae* (Miller & Wolf) Monod does belong in the Diaporthales, and the horizontal ascomata with lateral beaks that lack a stromatic capsule, suggest that the species is better assigned to *Pleuroceras* as *P. gleditschiae* (Miller & Wolf) Barr, comb. nov. (basionym: *Linospora gleditschiae* Miller & Wolf, Mycologia 28: 177-179. 1936).

Monod recognized two species of *Pleuroceras* on Quercus: *P. quercicolum* (Kobayashi) Monod from Japan and *P. quercinum* (Teng) Monod from China. Another species, on *Quercus garryana* Douglas, has one-septate ascospores that although shorter are similar in shape to those of *P. groenlandicum* on *Salix*. This species develops in thin twigs and forms no stromatic tissues.

Pleuroceras virgularum Barr, sp. nov. Figs. 11-13

Ascomata immersa horizontalia 400 µm lata 300 µm alta, rostra lateralia vel 200 µm alta 100 µm lata. Asci unitunicati 70-80 x 15-17 µm, annuli vadosii, aparaphysati. Ascosporae 36-50 x 4-5 µm hyalinae elongatae fusoideae uniseptatae, appendiculae setaceae ad 2 um, fasciculatae. In virgulis *Querci garryanae*. Holotypus "British Columbia: Vancouver Island, Sidney, 24 Aug 1990," lectus M. E. Barr 7262, in DAOM et NY depositus.

Ascomata immersed separately or two together, horizontal, 400 µm wide, 300 µm high; beak lateral, short, up to 200 µm high, 100 µm wide, ostiole periphysate; peridium narrow, 20-25 µm, of few rows of compressed cells, dark brown externally. Asci 70-80 x 15-17 µm, numerous, floating free, 8-spored or 2 or 4 maturing; apical ring shallow. Ascospores 36-50 x 4-5 µm, hyaline, elongate fusoid, slightly wider above and tapered toward base, 1-septate, nearly median; wall smooth, short setose terminal appendages, ca. 2 µm long; two or three globules per cell; in one or two fascicles in the ascus.

In twigs of *Quercus garryana*. Additional collections: British Columbia: Vancouver Island, Sidney, 19 Aug 1990, M. E. Barr 7259, 13 Oct 1990, M. E. Barr 7340, 6 Feb 1991, M. E. Barr 7421 (DAOM).

Key to North American Species of *Pleuroceras*

1. Ascospores over 100 µm long; in *Salix*.................2

1. Ascospores less than 100 µm long......................3

  2. Ascospores with elongate bristle-like appendages, (75-)110-130 x 2-3 µm....................*P. insulare*

  2. Ascospores lacking appendages, 160-240 x 1-1.5 µm...................................*P. helveticum*

3. Ascospores constricted at median septum, 48-70 x 3.5-4 µm..*P. populi*

3. Ascospores not constricted at median septum..........4

  4. Ascospores with long bristle-like appendages.....5

  4. Ascospores lacking appendages or appendages short. 6

5. Ascospores 45-60 x 0.5-1-2 µm; in *Salix*...*P. oregonense*

5. Ascospores 20-36 x 1-2 µm; in *Acer*..........*P. tenellum*

  6. Ascospores fusoid, 36-50 x 4-5 µm; in *Quercus*..... ....*P. virgularum*

  6. Ascospores filiform, 1.5-3 µm wide...............7

7. Ascospores 48-63(-72) x 1.5-2.5 µm; in *Salix*.......... ....*P. labradorense*

7. Ascospores 70-90 x 3 µm; in *Gleditschia*.*P. gleditschiae*

Winterella Kuntze 1891 non Berlese 1894 nec Saccardo 1897. This name is the correct one to replace *Cryptospora* Tulasne & C. Tulasne 1863 non Karelin & Kirilow 1842, *Ophiovalsa Petrak, and the type species of Cryptosporella* Sacc. 1877. Most of the species hitherto listed in *Cryptosporella* belong in *Wuestneia* in the Melanconidaceae, i.e. with firm-walled, more ovoid ascospores. Reid and Booth (1987, 1989) discussed nomenclatorial ramifications of these names. In *Winterella* (Reid and Booth 1987), the ascospores are thin-walled, elongate fusoid or filiform or femuroid (wider toward tips), and ascomata are in valsoid configuration in slight or well developed stromatic tissues. Reid and Booth recognized nine species and one subspecies in branches of woody plants in North America.

Melanconidaceae

The family now includes the Pseudovalsaceae Barr and is separated from the Gnomoniaceae and Valsaceae chiefly on the bases of ascospores -- firm walled, hyaline or pigmented, amero-, didymo-, phragmo- or dictyosporous (Barr 1990). A few changes and additions are proposed in several genera.

Caudospora taleola (Fr.) Starb. is separated from *Diaporthe* where Wehmeyer (1933) included this taxon, by the firm-walled ascospores that are verruculose and have both median and terminal appendages (Rogers 1984).

Dicarpella. *Dicarpella bina* (Harkness) Sydow & P. Sydow is the type species, on *Quercus agrifolia* in California, has pseudoparenchymatous tissues closely surrounding the apex of ascomata, and the ascospores are two per ascus, 18.5-25 x 7.5-12 µm. Barr (1979) transferred *D. quercifolia* (Ellis & Everh.) Barr, but this species and *D. georgiana* (Miller & Thompson) Barr should be removed from the genus because of the prosenchymatous clypeus (ectostromatic disc) that covers one or a few ascomata (Reid, personal communication). Monod (1983) added *D. orientalis* (Ellis & Everh.) Monod and *D. liquidambaris-styracifluae* Monod to the genus, both with eight-spored asci. The latter was segregated from *D. georgiana* (Miller & Thompson) Barr, which is limited to collections on *Nyssa* that Monod retained under *Gnomoniella.*

Dictyoporthe now has *D. canadensis* (Ellis & Everh.) Barr on *Carpinus* (Barr 1983) in addition to *D. acerophila* Barr in North America.

Hapalocystis corni (Wehm.) Barr was added to the genus (Barr 1979), with small ascospores, 16-25 x 7-9 µm.

Mebarria thujina (Nag Raj & DiCosmo) Reid & Booth was separated from "Cryptosporella" by Reid and Booth (1989) in their revision of *Wuestneia.* The two genera differ in configuration of ascomata and in ascospore pigmentation.

Melanamphora spinifera (Wallr.) LaFlamme (LaFlamme 1976) is segregated from *Pseudovalsa.*

Phragmoporthe. Monod (1983) submerged *Magnaporthe* Krause & Webster under this genus. *Magnaporthe* has been reassigned to the Hyponectriaceae (Xylariales) (Barr 1977, 1990) because of centrum structure and anamorphs. *Phragmoporthe conformis* (Berk. & Broome) Petrak belongs in the series of genera *Dicarpella, Sydowiella, Ditopella* as a phragmosporous representative.

Plagiophiale. The type species *Plagiophiale petrakii* (Müller) Petrak was transferred as *Plagiostoma petrakii* (Müller) Monod. The firm-walled ascospores and slight prosenchymatous clypeus separate the genus from *Plagiostoma*. Vasilyeva (1987) assigned *Plagiophiale* to the Cainiaceae which she placed in the Sordariales. Another species is added to *Plagiophiale*, smaller than *P. petrakii*, and with straplike appendages on the ascospores, for which this species is named.

Plagiophiale ligulata Barr, sp. nov. Figs. 14-16

Ascomata immersa seriata horizontalia 130-220 µm lata, rostra lateralia 75-90 µm alta 52-65 µm lata. Asci unitunicati 35-45 x 15-17 µm, sine annuli, aparaphysati. Ascosporae 18-22 x 6-7.5 µm hyalinae demum brunneolae ellipsoideae uniseptatae, appendiculae ligulatae 5-8 x 2 µm, aggregatus. Holotypus in culmis *Elymi arenarii* L., "Maine: Kresge Point, New Harbor, 29 Jul 1965," lectus M. E. Barr 4787a, in NY depositus.

Ascomata gregarious in rows, horizontal, 130-220 µm wide; beak lateral, short, 75-90 µm high, 52-65 µm wide; peridium narrow, light yellowish brown, with prosenchymatous coating of brown hyphae. Asci 35-45 x 15-17 µm, broadly ellipsoid, apical ring not seen. Ascospores 18-22 x 6-7.5 µm, hyaline, dull brownish after discharge, ellipsoid, ends obtuse, one-septate median; wall firm, smooth, terminal appendages straplike, 5-8 x 2 µm, folded back over body of ascospore; one or two globules per cell; crowded in the ascus.

Known only from the type collection.

Sydowiella. Monod (1983) mentioned the genus but excluded it from further consideration. Vasilyeva (1987) erected the Sydowiellaceae in the Ceratostomatales to accommodate *Sydowiella*. Neither author recognized that individual ascomata are surrounded by a pseudoparenchymatous stroma, much as in *Dicarpella and Phragmoporthe*.

Wehmeyera acerina (Wehm.) Reid & Booth is another segregate from "Cryptosporella" (Reid and Booth 1989). It differs from *Wuestneia* in the presence of a pseudoparenchymatous stroma in the form of ectostromatic disc over grouped but upright ascomata. In both genera the ascospores are hyaline, one celled and have a thickened wall.

Wuestneia Auerswald is an earlier name for the species placed in *Cryptosporella*. Stromatic tissues are prosenchymatous, light to bright pigmented and ascomata are valsoid in configuration. Seven taxa from North America are well described and illustrated by Reid and Booth (1989).

I am indebted to C. T. Rogerson who reviewed this manuscript and to collectors noted in the text for significant specimens and comments.

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MYCOTAXON

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PUCCINIA TETRAGONIAE VAR. NOVAE-ZELANDIAE VAR. NOV. AND UREDO CHATHAMICA SP. NOV. FROM CHATHAM ISLANDS, NEW ZEALAND

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The Chatham Islands lie approximately 860 km east of the South Island of New Zealand. The group, with a total land area of less than 100,000 ha is comprised of two main islands (Rekohu or Chatham and Rangiauria or Pitt) and several smaller islands, rocks and stacks. The vascular plant flora includes about 320 native species with 37 endemic plant taxa (Given & Williams 1985).

The author visited Chatham Islands in 1983, and an annotated list of all fungi known from this island group has been produced (McKenzie 1991). During this visit, telia of *Puccinia tetragoniae* were found for the first time in New Zealand on leaves of *Tetragonia tetragonioides*. The specimen forms the basis for description of a new variety, *novae-zelandiae*. An undescribed species, *Uredo chathamica*, was found on two *Carex* species. This rust was also discovered during an examination of *Carex* specimens in two botanical herbaria. This paper describes the fungi and compares them with other rust fungi previously known on these hosts.

Puccinia tetragoniae McAlpine var. **novae-zelandiae** McKenzie var. nov. Fig. 1A
Uredo novae-zelandiae Laundon, *Mycological Papers 91*: 16, 1963

Teliis amphigenis, rufo-brunneis, circinnatis. Teliosporae 42-50 x (29-) 32-35 (-36) μm, late ellipsoideae vel cylindricae, interdum acuminatae, ad septum constrictae, membrana ad latera 3-6 μm, ad apicem (5-) 7-10 μm crassae, leves, castaneo-brunneae; pedicello usque ad 60 μm, pallide luteo.

In foliis aizoaceae speciei *Tetragoniae tetragonioidis* (Pallas) Kuntze
Holotypus PDD 56064.

Telia amphigenous, reddish-brown, in circinnate groups surrounding the uredinia, long covered. Teliospores 42-50 x (29-) 32-35 (-36) μm, broadly ellipsoidal to cylindrical, sometimes acuminate, usually constricted at septum, wall 3-6 μm thick at sides, (5-) 7-10 μm at apex, smooth, chestnut brown; pedicels up to 60 x 6-11 μm, but usually broken shorter, pale luteus.

On *Tetragonia tetragonioides* (Pallas) Kuntze
Specimen examined: Rekohu, Waitangi, 13.III.1983, E. H. C. McKenzie

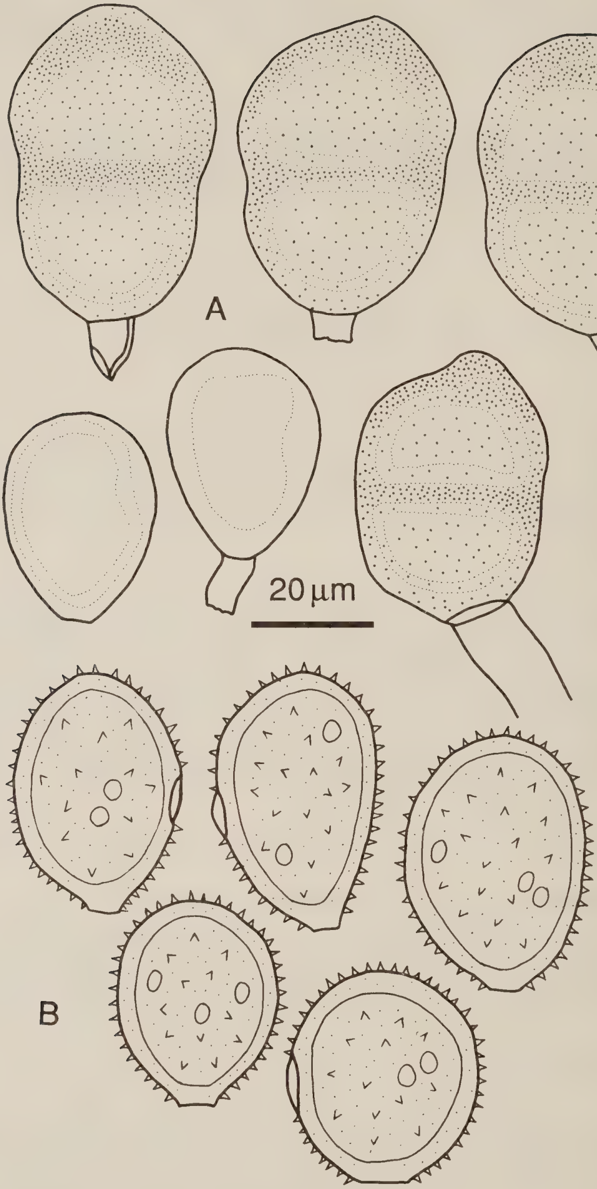

Figure 1. A, *Puccinia tetragoniae* var. *novae-zelandiae*, teliospores and urediniospores (PDD 56064 - type). B, *Uredo chathamica*, urediniospores (PDD 44228 - type). Specimens mounted in hydrous lactophenol.

(PDD 56064 - **holotype**) 0, II, III.

Although Cunningham (1923, 1931) described teliospores of *P. tetragoniae*, it is likely that these were described from Australian material since Laundon (1963) did not see any on New Zealand specimens examined during his revision of rusts on *Tetragonia*. Laundon distinguished three varieties under *P. tetragoniae* on the basis of urediniospore morphology (size and wall layer thickness) and geographical distribution, viz, var. *tetragoniae* on *T. implexicoma* (Miq.) Hook. f. in Australia, var. *austro-africana* E. M. Doidge on *T. tetragonioides* in South Africa, and (*P. tetragoniae* var.) *Uredo novae-zelandiae* Laundon on *T. tetragonioides* and *T. trigyna* Banks & Sol. ex Hook. f. in New Zealand. Although teliospores were unknown for New Zealand collections of the rust, Laundon had little doubt that the rust belonged in this complex.

Urediniospores from the Chatham Islands collection measure (27.5-) 29-32 (-35) x (22-) 24-27 μm, mean 31 x 25 μm, with the inner wall layer 1-2 μm thick and the outer layer 1-3 μm thick. These measurements are similar to those given by Laundon (1963) for *Uredo novae-zelandiae*.

Uredo chathamica McKenzie sp. nov. Fig. 1B

Urediniis plerumque hypophyllis (abaxialibus), cinnamomeo-brunneis, pulverulentibus, usque ad 1 mm longis. Urediniosporae (28-) 33-39 (-46) x (24-) 26-31 (-35) μm, globosae vel late ellipsoideae, membrana (1.5-) 2-3.5 (-4) μm crassa, aureo-brunnea, echinulata, poris germinationis 3-4, aequatorialibus.

In foliis cyperaceae speciei *Carex chathamica* Petrie et *C. trifida* Cav.
Holotypus PDD 44228.

Uredinia amphigenous, mainly on lower (abaxial) surface, cinnamon-brown, pulverulent, up to 1 mm long or confluent and linear, surrounded by the ruptured epidermis. Urediniospores (28-) 33-39 (-46) x (24-) 26-31 (-35) μm, globose or broadly ellipsoidal, wall (1.5-) 2-3.5 (-4) μm thick, golden-brown, echinulate, germ pores 3-4, equatorial.

on *Carex chathamica* Petrie
Specimens examined: Rekohu, Mahahatau Creek, J. F. Findlay, Jan 1955 (PDD 42220 - CHR 97202); east of Te Whanga Lagoon, J. F. Findlay, Jan 1955 (PDD 42221 - CHR 97201); Owenga, 11.III.1983, E. H. C. McKenzie (PDD 44228 - **holotype**). Rangiauria, B. G. Hamlin, 1 Dec 1957 (PDD 41170 - WELT 3325).
on *Carex trifida* Cav.
Specimen examined: Rangatira (South East Island), B. Bell, Dec 1961 (PDD 42218 - CHR 158261, PDD 42219 - CHR 158260).

There are four species of rust fungi recorded on *Carex* in New Zealand. Urediniospores of *Uredo chathamica* differ from those of the four *Puccinia* spp. in size and number of germ pores. *Carex chathamica* is endemic to the Chatham Islands, while *C. trifida*, which is indigenous to the South Island and the subantarctic islands of New Zealand, also occurs in Chile and the Falkland Islands.

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CONIDIAL GERMINATION IN EUTYPA ARMENIACAE AND SELECTED OTHER SPECIES OF DIATRYPACEAE: IMPLICATIONS FOR THE SYSTEMATICS AND BIOLOGY OF DIATRYPACEOUS FUNGI

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The seminal work of the Tulasne brothers (Tulasne and Tulasne, 1861-1865) convinced mycologists of the need to base pyrenomycete taxonomy on an understanding of complete life cycles, considering information on both sexual and asexual states. As in all taxonomic approaches, this one is based on identifying homologous characters that can be compared among taxa. Although determining homologies among sexual states of different groups is relatively straightforward (e.g., ascospores in one taxon can safely be regarded as homologous with ascospores of other taxa), homologies among asexual states frequently are more difficult to establish because of the extreme variation exhibited in asexual spore morphology, ontogeny, and function. In addition, the varying numbers of asexual spore states involved in the life cycles of different pyrenomycetes can complicate comparisons of spore states. One of the best clues regarding possible homologies is the function of a spore state, since within groups of related fungi the role of a spore state in the life cycle seems relatively uniform.

Unfortunately, even this information is lacking for a number of pyrenomycetes, including the family Diatrypaceae.

Although various aspects of asexual states of the Diatrypaceae have been investigated (Glawe, 1989 and references therein), the function of asexual spores has not been determined with certainty, and Glawe and Rogers (1984) suggested that "one of the great mysteries of diatrypaceous fungi is the function of the conidia." Among Diatrypaceae, *Eutypa armeniacae* Hansf. & Carter has received the most attention by scientists attempting to determine the function of the asexual state.

Eutypa armeniacae causes canker and dieback diseases of a wide range of host plants (Carter, 1957; Moller and Kasimatis, 1978; Carter et al. 1983). Prior to discovery of the sexual state (Carter, 1957), the *Cytosporina* state of the fungus was associated with a dieback disease of apricot (*Prunus armeniaca* L.) in Australia by Samuel (1933). In early pathogenicity studies on this fungus, Adam (1938) produced infections in apricot trees using conidial suspensions as inoculum, and Adam et al. (1952) later claimed that conidia were capable of serving as inoculum. However, Carter (1957) was unable to germinate the conidia on a variety of media and suggested that only ascospores function as inoculum. Although conidia sometimes were found to form lateral protrusions resembling incipient germ tubes (e.g., Moller and Kasimatis, 1978), recent authors have tended to assume that conidia were ingerminable, and that only ascospores are effective in spread of the fungus (e.g., Moller and Carter, 1965; Ramos et al., 1975; Moller and Kasimatis, 1978; Pearson, 1980; Glawe et al., 1982).

Researchers also have tried to germinate conidia in other species of Diatrypaceae. Tulasne and Tulasne (Vol. II, 1863) reported germination of conidia in *Eutypa acharii* Tul., but later workers failed to germinate conidia in various species (de Bary, 1887; Kliejunas and Kuntz, 1972; Johnson and Kuntz, 1978; Glawe and Rogers, 1982, 1984; Rogers and Glawe, 1983; Glawe and Jacobs, 1987). Although those studies did not demonstrate conidial germination, in a number of instances conidia produced bulges or protrusions suggestive of germ tubes (Glawe and Rogers, 1982; Rogers and Glawe, 1983), and conidia from an isolate of *Diatrype stigma* (Hoffm. : Fr.) Fr. *sensu lato* produced branching germ tube-like protrusions (Glawe and Jacobs, 1987).

In this paper we report the germination of conidia of *Eutypa armeniacae* and seven other diatrypaceous fungi. We also discuss implications of this finding for the systematics of the family and for understanding the biology of these fungi.

MATERIALS AND METHODS

A culture of *Eutypa armeniacae*, originally isolated from commercial grapevine (*Vitis labrusca* L.), was obtained from Dr. Dennis Johnson, Washington State University Irrigated Agriculture Research and Extension Center, Prosser. The fungus was grown on 2% potato dextrose agar (Difco) with 5 g/L yeast extract (Difco) (PDYA) in 9-cm-diam plastic Petri plates at ca. 20C, under alternating daily periods of ca. 12 h fluorescent light and 12 h darkness. The first conidia were produced in about 3 wk.

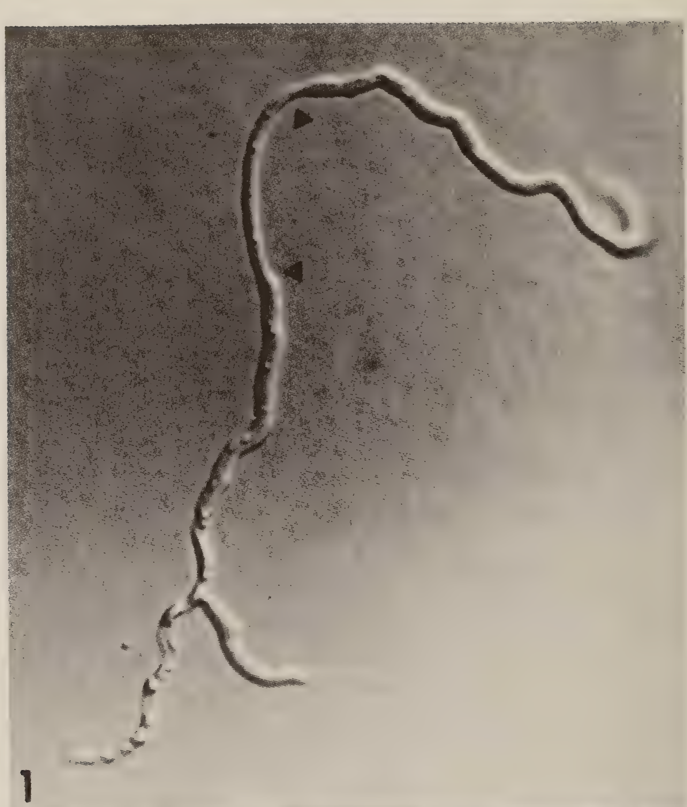
As soon as sporulation was observed, conidial masses were removed from cultures with a sterile loop and placed in the center of a PDYA plate. A small amount of sterile distilled water was then poured into the plate, which was gently agitated to disperse the conidia. This was repeated four different times with fresh cultures. Germinating conidia were located by scanning the agar surface using 10X. Blocks of agar with germinated conidia were removed to microscope slides, the relevant areas excised and mounted in water, and the conidia photographed. Drawings of germinated conidia were made with a camera lucida.

Conidia from seven other species were produced, treated, and examined in a manner similar to that described for *E. armeniacae*. These species, all from Taiwan, included *Eutypella aulacostroma* (Kunze: Fr.) Berl. (NTU-76122501), *Eutypella scoparia* (Schwein.: Fr.) Ellis & Everh. (NTU-77082321), *Eutypella curvispora* (Starb.) Rappaz (NTU-77072601), *Eutypella* spp. (NTU-77052201, NTU-77080304) (two taxa), *Eutypa hypoxantha* (Lév.) Starb. (NTU-77080305), and *Scoptria* sp (NTU-76100912). Cultures and collections are at WSP.

RESULTS

A total of 140 conidia of *Eutypa armeniacae* were found to germinate in the four trials. Calculations revealed that about 9,400,000 conidia had been present on the four plates. Thus, the rate of germination was about 0.0015%. Most conidia germinated within 2 days after dispersing them on PDYA plates, while some additional conidia were found germinating at periods of up to four days from the time they were placed on agar.

Most conidia germinated by producing a germ tube at each end while others germinated by forming a more medial,



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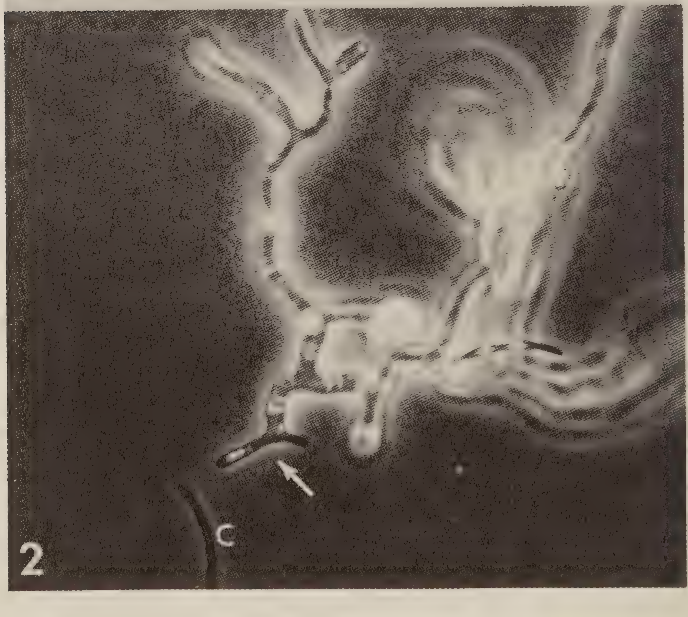

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lateral germ tube (Figs. 1-5). Germ tubes were usually of greater diameter than the conidia from which they originated. When germinated conidia were transferred to fresh PDYA plates they gave rise to normal colonies.

Similarly low numbers of conidia germinated in all of the other species studied.

DISCUSSION

Conidia of *Eutypa armeniacae* and seven additional taxa among *Eutypa*, *Eutypella*, and *Scoptria* germinated in this study, albeit at low rates. The low rate of germination may account for the failure of many past researchers to report germination of diatrypaceous conidia. A further complication results from the fact that the elongate conidia are difficult to differentiate from portions of the mycelia they produce. Past attempts to germinate diatrypaceous conidia by streaking them on agar frequently resulted in the formation of mycelia, but such mycelia were not traced to identifiable germinating conidia and therefore were regarded as likely resulting from contaminating hyphal fragments (Glawe, unpublished). Possibly, such mycelia did result from conidial germination but the germinating conidia were not recognized. In this study there was no doubt that conidial germination progressed beyond stages reported previously for Diatrypaceae (Moller and Kasimatis, 1978; Glawe and Rogers, 1982; Rogers and Glawe, 1983; Glawe and Jacobs, 1987) to produce vigorously growing mycelia.

Given the marked similarities of diatrypaceous anamorphs (Glawe, 1989; Glawe and Rogers, 1984) it seems likely that conidia of other Diatrypaceae also will be found to be germinable. Field studies are needed to determine the importance of conidia in dispersal, but it seems that conidia might be most effective in dispersal over relatively short distances, since they typically are produced in mucilage and presumably are splash-dispersed (Glawe and Rogers, 1986). It is also possible that conidia might yet be found to have a spermatial function, because much of the interior volume of conidia in investigated species is

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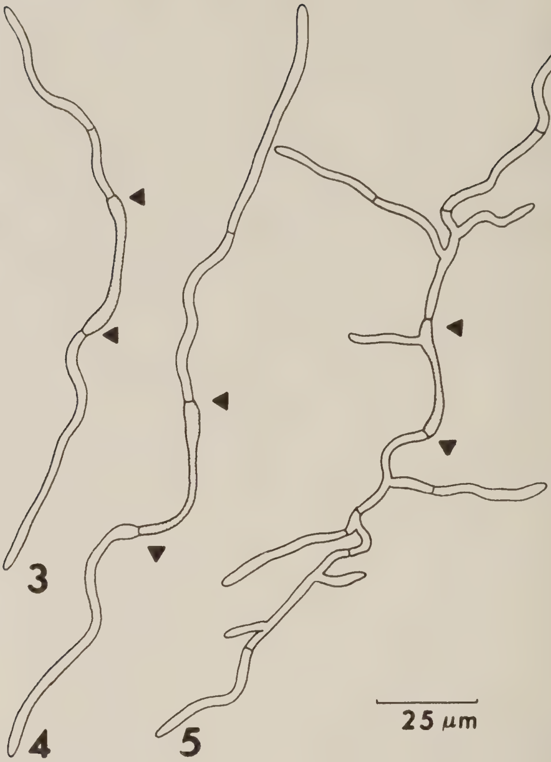
Fig. 1. *Eutypa armeniacae*. Germinated conidium. Germ tubes from ends of conidium (arrowheads). X 650. Fig. 2 *Eutypella aulacostoma*. Germinated conidium (arrow). Ungerminated conidium (c). X 650. Fig. 1 by differential interference contrast microscopy. Fig. 2 by dark field phase microscopy.



Figs. 3-5. *Eutypa armeniacae*. Germinated conidia, the ends of conidia marked by arrowheads. Conidium in Fig. 5 also producing a lateral germ tube. Figs. from camera lucida tracings.

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occupied by a large elongate nucleus (Jacobs and Glawe, 1988). If so, these conidia function somewhat as the microconidia in *Neurospora* species which serve as spermatia but are germinable in relatively small percentages (e.g., Alexopoulos and Mims, 1979). It is interesting to note that conidia of some taxa of Xylariaceae, a group allied to the Diatrypaceae and ecologically similar, also frequently germinate at low rates or not at all (Rogers, 1979). Physiological studies on germination will be useful in defining the conditions under which diatrypaceous conidia germinate and whether higher rates of germination than were found in this study can be expected.

The discovery that diatrypaceous conidia can germinate has important implications for the systematics of this rather poorly known family. The similar tendencies in conidial germinability of Diatrypaceae and Xylariaceae seem to underscore similarities in conidial ontogeny (Glawe and Rogers, 1986; Glawe 1989) and conidial nuclei (Jacobs et al., 1988). On the other hand, beta conidia of *Diaporthe* species also are known to form lateral protrusions reminiscent of those reported previously for Diatrypaceae (Jensen, 1983), suggesting that under appropriate conditions they might also be capable of germination. Thus, while the results of the present study seem to support the idea that diatrypaceous and xylariaceous conidia are homologous, it is difficult to know whether or not diatrypaceous conidia should be regarded as being homologous with diaporthaceous alpha conidia, or with beta conidia, or with both kinds of conidia. Further studies are needed to address this problem.

Determining that diatrypaceous conidia can germinate has important implications for disease cycles involving diatrypaceous plant pathogens. Even though very low rates of germination were seen in this study, under suitable conditions higher germination rates might occur. Even if germination rates of conidia are similarly low in nature, the huge numbers of conidia produced by each pycnidium may include sufficient germinable conidia to serve as a significant source of inoculum. Past epidemiological studies have focussed almost exclusively on the role of ascospores in dispersal, but it now seems plausible that conidia might also serve as inoculum. Conidial inoculum might be significant in arid regions, such as parts of Australia, Washington, and California where the fungus causes diseases of susceptible hosts, but where conditions are too dry for the sexual state to form (Carter, 1957; Glawe et al., 1982; Moller and Carter, 1965; Ramos et al., 1975). In these areas, it has been suggested that ascospores are produced in wetter regions ranging from 50 to 160 km away, and that discharged ascospores are carried long distances by air currents. The observation of the conidial state of *E. armeniacae* in arid, central Washington (Glawe et al., 1982) seems significant, especially because this anamorph is easily overlooked and its incidence in nature seems likely to have been underestimated in the few instances in which it has been sought. Further efforts to determine the incidence of the asexual state, and studies on the effectiveness of conidial inoculum are needed to provide a clearer picture of the epidemiology of eutypa dieback diseases. Similar studies are also needed for the economically and ecologically important diatrypaceous plant pathogens *Eutypella parasitica* Davidson & Lorenz and *Cryptosphaeria populina* (Pers. : Fr.) Sacc. (Hinds, 1981). Because past research on diatrypaceous pathogens has tended to discount any possible role of conidial states, such studies may provide hitherto unexpected insights into the biology and control of these fungi.

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A NEW SPECIES OF *EXOPHIALA* RECOVERED FROM DRINKING WATER

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ABSTRACT

A new species, *Exophiala angulospora* Iwatsu, Udagawa et Takase, isolated from drinking well water in Japan, is described and illustrated. This fungus is characterized by having more commonly angular (tri- or tetragonal in longitudinal view) conidia with rounded ends rather than an obovoid, ellipsoidal or oblong form.

During a pollution assessment of drinking well water in Yokohama City in Japan, an interesting dematiaceous hyphomycete was detected and isolated. Although this fungus was found to be a typical member of *Exophiala* Carmichael (Carmichael, 1966), it is clearly distinct from all hitherto described species of the genus. Therefore, it is described herein as a new species.

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Exophiala angulospora Iwatsu, Udagawa et Takase, sp. nov. (Figs. 1, 2)

Coloniae in agaro farinae avenae restrictae, floccosae, ad centrum partim humidae, atrovirides vel nigrae; reverso atroviridi vel nigro. Coloniae in agaro "potato-carrot" restrictae, floccosae, constantes ex mycelio tenui, griseo-brunneae vel nigrae; reverso atroviridi. Mycelium ex hyphis hyalinis vel pallide olivaceo-brunneis vel brunneis, ramosis, levibus, crassiusculis, septatis, 1.5–3 µm diam, interdum irregulariter inflatis compositum; saepe fasciculatum. Cellulae gemmatae praesentes. Cellulae germinantes plerumque inflatae, leves, crassiusculae, 6–10 X 2.5–4 µm, in cellulas breves ventricosas patulae, quae deinde in hyphas longas angustatas transiens. Apparatus conidicus saepe distinctus, erectus, capitulum densum formans. Cellulae conidiogenae annellidicae, intercalares, laterales vel terminales, lageniformes vel cylindricae, 6–16 X 2.5–3 µm, prope basim septatae, ad rostrum breve angustatae. Conidia unicellularia, in capitulum mucosum aggregata, hyalina vel pallide olivacea, levia, basi subtruncata, diversiformia, (1) plerumque angulata, cum extremis rotundata, plus minusve incrassata, 2.5–4 X 2–3 µm, et (2) interdum obovoidea, ellipsoidea vel oblonga, 2.5–6 (-8) X 1.5–3 µm.

Ubiquinonum majus: Q-10.

Teleomorphosis ignota est.

Holotypus: Colonia exsiccata ex aqua potabili, Yokohama, in Japonia, 18.iv.1989, a K. Arai isolata, NHL 3101. In collectione fungorum "National Institute of Hygienic Sciences (NHL), Tokyo."

Etymology: from Latin *angulus*, angle, and *-sporus*, seed, referring to the shape of conidia.

Colonies on oat-meal agar growing restrictedly, floccose, partly wettish in the central area, Dark Green (26F3-4: Kornerup and Wanscher, 1978) to Black (1F1); reverse Dark Green (27F4) to Black (1F1). Colonies on potato-carrot agar growing restrictedly, floccose, consisting of a thin mycelium, Greyish Brown (7F3-4) to Black (1F1); reverse Dark Green (27F3). Mycelium composed of hyaline to pale olivaceous or brown, branched, smooth, rather thick-walled, septate, 1.5–3 µm diam, sometimes irregularly swollen

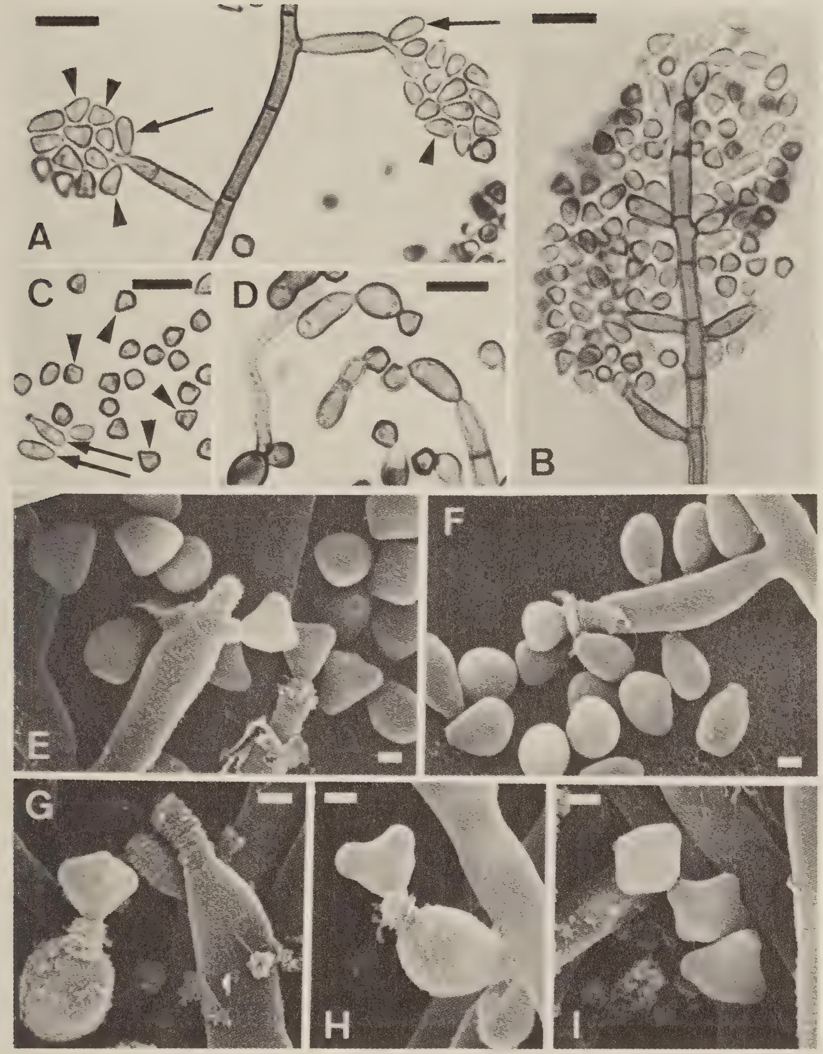

Fig. 1. *Exophiala angulospora*, NHL 3101.
A–D) Light micrographs (scale bars: 10 µm): A. Conidiogenous cells, angular conidia (arrow heads) and obovoid-ellipsoidal conidia (arrows); B. Whole conidial apparatus; C. Angular conidia (arrow heads) and ellipsoidal conidia (arrows); D. Germination of angular conidia. E–I) SEM micrographs (scale bars: 1 µm): E, G–I. Conidiogenous cells and angular conidia ; F. Conidiogenous cell and obovoid-ellipsoidal conidia.

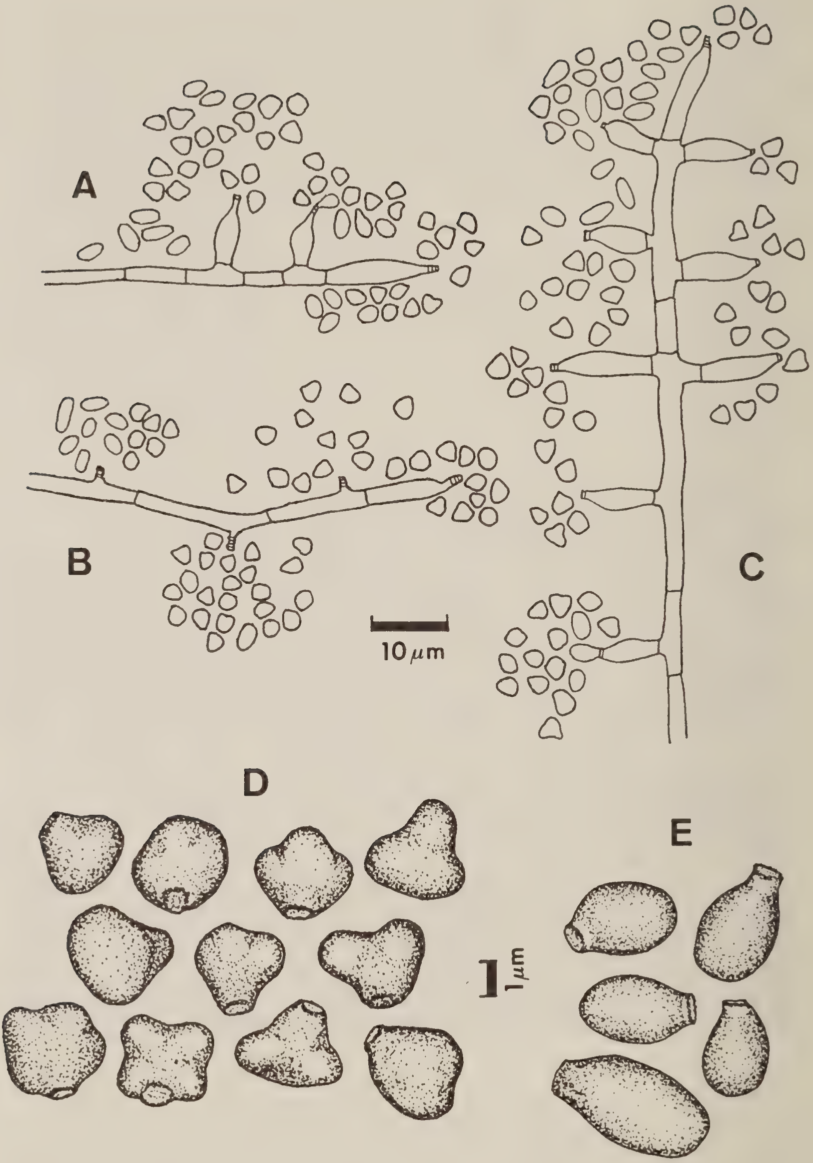

Fig. 2. *Exophiala angulospora*, NHL 3101.
A, B) Conidiogenous cells and conidia.
C) Whole conidial apparatus. D) Angular conidia.
E) Obovoid-ellipsoidal conidia.

hyphae; often forming a bundle. Budding cells present. Germinating cells usually inflated, smooth, thick-walled, 6–10 X 2.5–4 µm, giving rise to short, swollen cells that change to long, narrow hyphae. Conidial apparatus often differentiated, erect, forming a dense head. Conidiogenous cells annellidic, intercalary, lateral or terminal, flask-shaped or cylindrical, 6–16 X 2.5–3 µm, septate near the base, narrowing into a short beak. Conidia 1-celled, aggregating in a slimy head, hyaline or pale olivaceous, smooth, subtruncate at the base, variable in shape, (1) commonly angular (usually tri- or tetragonal in longitudinal view), with rounded ends, more or less thick-walled, 2.5–4 X 2–3 µm, and (2) sometimes obovoid, ellipsoidal or oblong, 2.5–6(–8) X 1.5–3 µm.

Major ubiquinone: Q-10.

Teleomorph is unknown.

At 37°C, growth is nil.

Specimens examined: NHL 3101 (holotype) and NHL 3102, isolated from drinking well water in Yokohama-shi, Japan, 18.iv.1989, coll. K. Arai. The specimens studied and living cultures derived from them are preserved at the National Institute of Hygienic Sciences, Tokyo, Japan.

The genus *Exophiala* was established by Carmichael (1966) to accommodate *E. salmonis* Carmichael, a pathogen of fingerling trout. Subsequently, several species have been added to the genus. Among them, *E. pisciphila* McGinnis et Ajello (McGinnis and Ajello, 1974), *E. spinifera* (Nielsen et Conant) McGinnis (McGinnis, 1977a), *E. jeanselmei* (Langer.) McGinnis et Padhye (McGinnis and Padhye, 1977), *E. moniliae* de Hoog (de Hoog, 1977), *E. dopicola* Katz et McGinnis (Katz and McGinnis, 1980) and *E. alcalophila* Goto et Sugiyama (Goto *et al.*, 1981) are widely accepted species (de Hoog and McGinnis, 1987). *Exophiala brunnea* Papendorf (Papendorf, 1969) is considered as a synonym of *E. salmonis* (de Hoog, 1977). A well-known human pathogen, *E. dermatitidis* (Kano) de Hoog (de Hoog, 1977), is now generally classified in *Exophiala*, although McGinnis (1977b) considered it to be the more appropriately classified in the genus *Wangiella* McGinnis. *Exophiala castellanii* Iwatsu *et al.* was described by one of the authors (Iwatsu *et al.*, 1984) to solve the taxonomic confusion surrounding *E. mansonii* (Castell.) de Hoog (de Hoog, 1977), but is now considered as one of the varieties of *E. jeanselmei* (Iwatsu and Udagawa, 1990). *Hortaea werneckii* (Horta) Nishimura et

Miyaji (Nishimura and Miyaji, 1984) was once classified in this genus as *E. werneckii* (Horta) v. Arx (von Arx, 1970), but is now separated. According to de Hoog and McGinnis (1987), most known teleomorphs with *Exophiala* anamorphs are classified in the ascomycete family Herpotrichiellaceae; viz. unnamed *Exophiala* species reported in *Capronia acutiseta* G. J. Samuels, *C. coronata* G. J. Samuels, and *C. villosa* G. J. Samuels (Müller *et al*., 1987). Recently, Pedersen and Langvad (1989) have described *E. psychrophila* O. Pedersen et Langvad as a pathogen of Atlantic salmon.

Exophiala angulospora differs from previously described species of *Exophiala* in having more commonly angular conidia rather than an obovoid, ellipsoidal or oblong form. On the other hand, other species of the genus have only the latter form. In addition, the fertile, conidium-bearing portions of the hyphae of *E. angulospora* are rather more differentiated when compared to those of other species.

Recently, Yamada *et al*. (1989) have reported that two main groups in the genus *Exophiala* can be distinguished on the basis of coenzyme Q systems: (1) Psychrophilic fish-pathogens, containing the generic type species *E. salmonis*, and *E. pisciphila*, both having Q-10 (H_2), and (2) Human-pathogenic species, containing *E. dermatitidis*, *E. jeanselmei*, *E. moniliae* and *E. spinifera*, and non-pathogenic species of *E. alcalophila*, all of which have Q-10. *Exophiala angulospora* has Q-10 and is thought to belong to the latter group.

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NEW COMBINATIONS AND SYNONYMY IN BIPOLARIS AND CURVULARIA, AND A NEW SPECIES OF EXSEROHILUM

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Bipolaris pluriseptata (Khetarpal, Nath & Lal) comb. nov., *B. portulacae* (Rader) comb. nov., *B. salviniae* (Muchovej) comb. nov. and *Curvularia heteropogonicola* (Sivan.) comb. nov. are proposed, and some synonymy is indicated. A *Cochliobolus* teleomorph is confirmed for *B. micropus* (Drechsler) Shoem., for which *Exserohilum paspali* Muchovej & Nesio is shown to be a synonym. *Exserohilum fusiforme* sp. nov. from *Echinochloa crus-galli* is described and illustrated. Brief notes are provided on *B. palousensis* Sprague, *Cochliobolus sporoboli* Castellani, *Drechslera patereae* Carranza and *Helminthosporium atypicum* K.S. Deshpande & K.B. Deshpande.

Key words: *Bipolaris, Curvularia, Exserohilum,* Taxonomy

This paper deals with a miscellany of observations relating to new combinations and synonymy in *Bipolaris* and *Curvularia*, and a new species of *Exserohilum.* Media mentioned in the text are PDA (potato dextrose agar), SMA (Sachs agar + maize leaf), WSA (water agar + wheat straw) and V-8A (15% V-8 juice agar). Cultures were grown under near-ultraviolet light (nuv, 12 h photoperiod, room temperature) to stimulate conidial sporulation, or on SMA in darkness when producing teleomorphs.

Bipolaris pluriseptata (Khetarpal, Nath & Lal) Alcorn, comb. nov.
Drechslera pluriseptata Khetarpal, Nath & Lal, *Ind. Phytopath.* 37: 320 (1984).

Conidial morphology of *B. pluriseptata* is similar to that of *B. curvispora* (El Shafie) Sivan., and Sivanesan (1987) considers these species to be synonymous. *B. pluriseptata* is here maintained as distinct following comparisons with cultures of each species grown under identical conditions. On SMA exposed to nuv, conidiophores of *B. pluriseptata* are shorter and thicker than those of *B. curvispora,* 95-215 µm long x 6.5-7.5 µm at the tip compared with 155-475 x 5-

6 µm. Conidia of *B. pluriseptata* are darker and often have a paler basal cell, are longer (up to 290 µm compared with 235 µm) and have more septa (8-21 cf. 8-13). Also they are more strongly curved, often more or less U-shaped, occasionally horseshoe-shaped (pers. obs.; Khetarpal, Nath & Lal, 1984). *B. pluriseptata* was not interfertile with tester strains of *Cochliobolus melinidis* Alcorn, the teleomorph of *B. curvispora,* when tested in 1987 and 1989.

Cultures examined: *D. pluriseptata*. ITCC 3131 ex type, *Eleusine coracana* (L.) Gaertn., Zambia, Feb. 1981 (BRIP 14895); IMI 259810 ex ITCC 3131 (BRIP 14839).

Bipolaris portulacae (Rader) Alcorn, comb. nov.
Helminthosporium portulacae Rader, *Mycol.* 40: 344 (1948).
Drechslera portulacae (Rader) de Hoog & van Oorschot, *Proc. K. ned. Akad. Wet.* C 86: 59 (1983).
Bipolaris portulacae (Rader) Strider & Chi, *Plant Disease* 68: 826 (1984), *nom. inval.*, Art. 33.
Bipolaris novae-zelandiae Sivanesan, *Trans. Br. mycol. Soc.* 84: 406 (1985).
Drechslera helianthi Hulea, *Probleme de Protectia Plantelor* 1: 78 (1973), *nom. inval.,* Art. 36.
Drechslera helianthi Iliescu, Hulea & Bunescu, *Proc. 6th Internat. Sunflower Conf. (1974) Bucharest,* p. 665 (1975), *nom. inval.,* Art. 36.

Rader (1948) showed that *H. portulacae* was a virulent pathogen of *Portulaca oleracea* L., while Strider & Chi (1984) found that *P. grandiflora* Hook. was also susceptible. Iliescu, Hulea & Bunescu (1975) concluded that *D. helianthi* was not a pathogen of *Helianthus annuus* L., and this might be expected if *B. portulacae* is host specific. *B. novae-zelandiae* was isolated from cultivated soil, but the circumstances of its occurrence were not further elaborated (Sivanesan, 1985). *P. oleracea* occurs in New Zealand but has not been recorded as a host of *B. portulacae* there (Pennycook, 1989).

A characteristic feature of *B. portulacae* is a narrow dark transverse band near the conidium apex, and sometimes also the base, coincident with or adjacent to the region where the periclinal wall curves and becomes thinner. Sivanesan (1985) reported 'a thick dark tranverse septum at one or both ends' in conidia of *B. novae-zelandiae,* but the illustrations suggest he was referring to the bands described above. They were also noted by de Hoog & van Oorschot (1983) in the isolate they studied.

Sivanesan (1985) reported typical *Bipolaris* conidial septum ontogeny in *B. novae-zelandiae.* In cultures CBS 239.48 and NC 196 of *B. portulacae,* the position occupied by the primary conidial septum is variable, sometimes submedian and in other instances delimiting the basal cell. Iliescu *et al.* (1975) illustrated similar variability in *D. helianthi.* I have been unable to confirm Sivanesan's results for septum ontogeny with the culture IMI 222864. Germination in *B. portulacae* is predominantly bipolar, with germ tubes branching close to the conidium. The apical germ tube is axial, and the basal, semi-axial germ tube often displaces the hilum by its proximity.

In culture on PDA, isolates of *B. portulacae* produce large, feathery, branched aggregations of acicular cystals submerged in the medium. These deposits are up to 9 mm long, and occur abundantly in cultures of CBS 239.48 and NC 196, less so in IMI 222864. In cultures of BRIP 15158 the aggregations are less numerous and smaller. The microsclerotia produced by all isolates have been described by previous authors, but the presence of crystals apparently has not been noted (de Hoog & van Oorschot, 1983; Iliescu et al. 1975; Rader, 1948; Sivanesan, 1985). The possibility that the microsclerotia might be protothecia was explored by pairing the isolates listed below in all possible combinations on SMA, but no ascomata formed.

Cultures examined: CBS 239.48 from *Portulaca oleracea,* Watkins Glen, New York State, U.S.A., W.E. Rader, authentic for the name *H. portulacae* (BRIP 14541); NC 196 from *Portulaca* sp. (? *P. grandiflora*) seed, 1975, D.L. Strider (BRIP 14576); IMI 222864 from soil, Mouteka, New Zealand, 25 Oct. 1977, K.N. Brunette 12347, ex type collection of *B. novae-zelandiae* (BRIP 14837); *D. helianthi* from *Helianthus annuus,* Romania, comm. May 1986, H. Iliescu *s.n.* (BRIP 15158).

Bipolaris salviniae (Muchovej) Alcorn, comb. nov.
Drechslera salviniae Muchovej, *Trans. Br. mycol. Soc.* 72: 331 (1979).
Bipolaris curvispora (El Shafie) Sivan., *Mycological Papers (CMI)* 158: 47 (1987).
Drechslera curvispora El Shafie, *Trans. Br. mycol. Soc.* 78: 545 (1982) (issued 7 June).

Bipolaris melinidis Alcorn, *Mycotaxon* 15: 7 (1982) (issued 15 July).

The synonymy of *B. melinidis* with *B. curvispora* proposed by Sivanesan (1987) is accepted. A culture of *D. curvispora* (IMI 253986, ex type) was interfertile with an authentic isolate of *B. melinidis* (BRIP 12312) and with single-ascospore isolates of *Cochliobolus melinidis.* Single-ascospore progeny from the latter pairings produced ascomata in some paired cultures, and when back crossed to parental isolates.

The type collection of *D. salviniae* was destroyed by insects during the period 1980-1983, and no isotypes were preserved (Muchovej, pers. comm. 1989). However a culture ex type (IMI 228224) has recently become available from the IMI Culture Collection (Anon., 1988). The dried material preserved in IMI consists of the original slope culture, but it bears no conidia and therefore is unsuitable for lectotypification. Sporulating cultures on WSA and SMA, produced using the BRIP duplicate of IMI 228224, have been dried down and added to the IMI material: this specimen is here nominated as lectotype for the name *Drechslera salviniae* Muchovej. This taxon is identical with *B. curvispora* and *B. melinidis.* In addition, ascomata were formed in paired cultures with single-ascospore isolates of *C. melinidis,* and there was fertility within the first generation progeny from such pairings and in back crosses to parental isolates.

The cultures of *D. curvispora* and *D. salviniae* used in this work are of opposite mating type and form ascomata of *C. melinidis* freely in paired culture on SMA.

Cultures examined: *B. melinidis.* ex *Melinis minutiflora*, Kuranda, Queensland, Australia, 4 July 1977, K.G. Pegg (BRIP 12312); *D. curvispora.* IMI 253986 ex *Triticum aestivum,* Paraguay (BRIP 13795); *D. salviniae.* IMI 228224 ex *Salvinia auriculata,* Brazil, 1978, J.J. Muchovej (BRIP 16571).

Curvularia heteropogonicola (Sivan.) Alcorn, comb. nov.
Exserohilum heteropogonicola Sivanesan, *Trans. Br. mycol. Soc.* 83: 321 (1984).

This species is more appropriately accommodated in *Curvularia* because of the structure of the protruding hilum. It consists of a cylindrical, pedicel-like protrusion delimited by a septum (Fig. 5), and is similar to that occurring in other *Curvularia* spp. with an exserted hilum such as *C. andropogonis* (Zimm.) Boedijn and *C. cymbopogonis* (Dodge) Groves & Skolko (Ellis, 1966; Luttrell, 1977). This hilar structure is quite distinct from that of true *Exserohilum* species (Alcorn, 1983, 1988a). In addition, the median conidial cells are thicker-walled and sometimes darker than end cells, septa are accentuated by a dark band, and conidia are commonly 4-septate (Fig. 3), all characters typical of *Curvularia*.

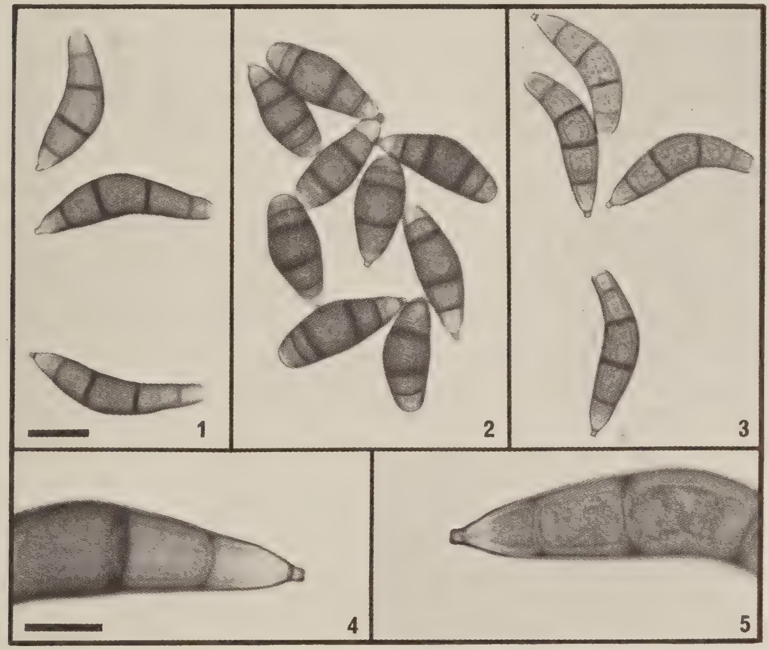


Fig. 1. *Curvularia heteropogonicola*, conidia from WSA (BRIP 16486b). Fig. 2. *C. heteropogonicola*, conidia from V-8A (BRIP 16486b). Fig. 3. *Exserohilum heteropogonicola*, conidia from WSA (IMI 268958). Fig. 4. *C. heteropogonicola*, detail of hilum (BRIP 16486b). Fig. 5. *E. heteropogonicola*, detail of hilum (IMI 268958). Bar (fig. 1) = 20 µm, figs 1-3; (fig. 4) = 10 µm, figs 4-5.

A fungus identical with *C. heteropogonicola* has been isolated from leaf spots on *Leersia hexandra* Swartz in Colombia (Figs 1,4). When grown on WSA, the latter isolate (BRIP 16486b) is indistinguishable from IMI 268958, the type culture of *E. heteropogonicola*. On V-8A the Colombian culture differs from *E. heteropogonicola* in producing two types of conidia: some like those formed on WSA, and darker, shorter and wider conidia resembling those of *C. cymbopogonis* (Fig. 2). The latter were 38-53 x 15-19 µm (mean 43.3 x 17.2 µm) compared with 55-75 x 12.5-16.0 µm (mean 64.8 x 14.2 µm) for the normal conidia. Cultures of this isolate on V-8A exposed to nuv are markedly zonate, having very dark mycelial bands of low elevation alternating with paler zones of higher elevation. The atypical conidia predominate in the low bands, and the narrower conidia in the high bands. Single-spore cultures from each conidial type were used to confirm this relationship to light conditions, and that only one taxon was represented in the primary isolate. Sivanesan (1987, Figs 63, 64) has illustrated similar conidial variability in *C. cymbopogonis,* and single-ascospore cultures of *Cochliobolus cymbopogonis* Hall & Sivan. examined by me show the same range in shape.

Curvularia heteropogonicola differs significantly from *C. cymbopogonis,* the most similar of the other species having 4-septate conidia with a protruding hilum. Cultures of each species were grown on SMA and WSA for comparison of conidial and conidiophore morphology and dimensions. Conidia of *C. cymbopogonis* are darker, less curved, shorter and wider (27-50 x 12.5-19.0 µm, means *ca* 37-41 x 14-17 µm) than those of *C. heteropogonicola* (40-65 x 10-14 µm, means *ca* 49-51 x 11-12 µm). There is also a striking difference in conidiophore length between the species. In *C. cymbopogonis* they are 75-240 µm long (means *ca* 95-195 µm) compared with 310-740 µm (means *ca* 443-658 µm) in *C. heteropogonicola).*

Specimens and cultures examined: *Curvularia cymbopogonis:* IMI 130402 ex *Sorghum bicolor,* Sudan, 1967, Fraser (BRIP 12647); ex *S. bicolor* grain, Sudan, A.E. El Shafie, comm. May 1982 (BRIP 10754); ex *S. bicolor,* Gladstone, Queensland, Australia, Aug. 1984, R.L. Dodman B49 (BRIP 14474); ex *S. plumosum,* Rifle Ck near Mt Molloy, Queensland, Australia, 30 Apr. 1987, J.L. Alcorn 8731c (BRIP 15799); ex *Bothriochloa bladhii,* Big Mitchell Ck, 20 km north of Mareeba, Queensland, Australia, 30 Apr. 1987, J.L. Alcorn 8757 (BRIP 15835). *Curvularia heteropogonicola:* IMI 268958 ex *Heteropogon contortus,* India, 27 June 1982, R.S. Adhikari (BRIP 14579); ex *Leersia hexandra,* Santander de Quilichao Research Station, Cauca Department, Colombia, 2 Aug. 1988, R.D. Davis (BRIP 16486b).

Cochliobolus state of Bipolaris micropus

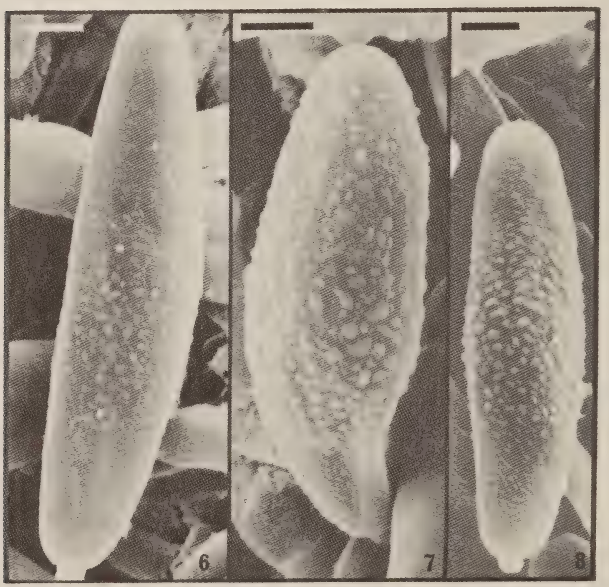
The fungus described as *Helminthosporium micropus* Drechsler (1923) was found to form 'rather immature perithecial fructifications' of *Cochliobolus* in culture (Drechsler, 1934). Luttrell (1958, 1977) produced mature *Cochliobolus* ascomata in paired cultures and proved the connection by single-ascospore isolations. An illustration showing an ascus and ascospore of this teleomorph has been published (Luttrell, 1973, p. 141), but no formal description has been offered.

In 1987 I was sent an isolate (lodged as BRIP 15689) originating from a forensic grass specimen in the U.S.A. (Rossman, pers. comm. 1987), and concluded that the fungus was *Bipolaris micropus* (Drechsler) Shoem. This supported other evidence that the host was *Paspalum notatum* Fluegge. Subsequent examination of the holotype of *Exserohilum paspali* Muchovej & Nesio (1987), and authentic cultures of this species (ATCC 62424; BRIP 16070), indicated close similarity between these taxa. When grown in paired culture with the isolate from *P. notatum* (BRIP 15689), both isolates of *E. paspali* formed a *Cochliobolus* teleomorph sparingly. Unfortunately, sufficient material to allow publication of an epithet in *Cochliobolus* for this taxon has not been produced, despite attempts using various combinations of isolates on a range of media.

Bipolaris micropus was excluded from *Exserohilum* by Leonard & Suggs (1974) on the basis of hilum structure, indicating that it is the basal part of the conidial wall rather than the hilum that protrudes. Subsequently this placement has been followed by Alcorn (1983) and Sivanesan (1987), and is supported by this confirmation of a *Cochliobolus* teleomorph. Another characteristic found useful in delimiting taxa at generic rank in the *Drechslera* - *Bipolaris* - *Exserohilum* complex is septum progression in maturing conidia. In this *B. micropus* is atypical, developing as do true *Exserohilum* spp. rather than in the usual manner of *Bipolaris* (Alcorn, 1983). This has been confirmed with the three isolates used in the work reported here.

A feature not mentioned in descriptions of *B. micropus* and *E. paspali* is roughening of the conidial wall (Drechsler, 1923; Sivanesan, 1987; Muchovej & Nesio, 1987). It is quite pronounced in the type specimen of *E. paspali* and derived cultures (Fig. 7), and less distinct in BRIP 15689 where it is commonly confined to the median region (Fig. 6). I have examined type material of *H. micropus* but very few conidia were found and they appeared to be smooth. Two subsequent collections determined as *H. micropus* by Drechsler bear more conidia, some of which are verruculose in the lower half. Conidia in the two Luttrell collections cited by Alcorn (1983) and Sivanesan (1987) are roughened in a manner similar to that in BRIP 15689. It appears that degree of conidial ornamentation in *B. micropus* is quite variable within and between collections, and the very prominent roughening present in *E. paspali* represents one extreme of this variability. The following synonymy is proposed.

Bipolaris micropus (Drechsler) Shoem., *Can. J. Bot.* 37: 884 (1959).
Helminthosporium micropus Drechsler, *J. agric. Res.* 24: 722 (1923).
Drechslera micropus (Drechsler) Subram. & Jain, *Current Science* 35: 354 (1966).
Exserohilum paspali Muchovej & Nesio, *Trans. Br. mycol. Soc.* 89: 126 (1987).



Figs 6-8. *Bipolaris micropus*, ornamentation of conidia. Fig. 6. BRIP 15689. Fig. 7. BRIP 16070 (*Exserohilum paspali*). Fig. 8. BRIP 16067, single-ascospore progeny from ATCC 62424 x BRIP 15689. Scale bars = 5 µm.

Sivanesan (1987) lists *H. leptochloae* Nisik. & Miyake as a synonym of *B. micropus.* The culture CBS 196.29 deposited by Nisikado is very similar to *E. rostratum* (Drechsler) Leonard & Suggs, as is also suggested by the original description (Nisikado & Miyake, 1924).

Specimens and cultures examined: (anamorph) ex *Paspalum notatum,* Lakeland, Florida, U.S.A., 3 Apr. 1970, E.S. Luttrell 8452 (BRIP 6516); ex *P. notatum,* Tifton, Georgia, U.S.A., 17 July 1970, E.S. Luttrell 8530 (BRIP 6520); on *P.? boscianum* Fluegge, Wauchula, Florida, U.S.A., 2 May 1921, C. Drechsler, type (BPI; BRIP 12436); on *P.? boscianum,* Charleston, S. Carolina, U.S.A., 13 June 1932, C. Drechsler (BPI); on *P.? boscianum* Fluegge, Charleston, S. Carolina, U.S.A., 23 June 1932, C. Drechsler (BPI); ex *P.? notatum,* U.S.A., comm. 3 Apr. 1987, A.Y. Rossman (BRIP 15689); on *P. conjugatum* Bergius, Vicosa, Brazil, 10 May 1986, J.J. Muchovej, holotype of *Exserohilum paspali* (BRIP 16098); ex *P. conjugatum*, Vicosa, Brazil, 10 May 1986, J.J. Muchovej, ATCC 62424 ex holotype collection (BRIP 15966); same details, comm. Jan. 1988, J.J. Muchovej *s.n*. (BRIP 16070); single-ascospore isolate ex BRIP 15689 x ATCC 62424, Dec. 1987, J.L. Alcorn 87105 (BRIP 16067); (teleomorph) on Sachs' agar + *P. notatum* seed, BRIP 15689 x 16070, Apr. 1988 (BRIP 16318).

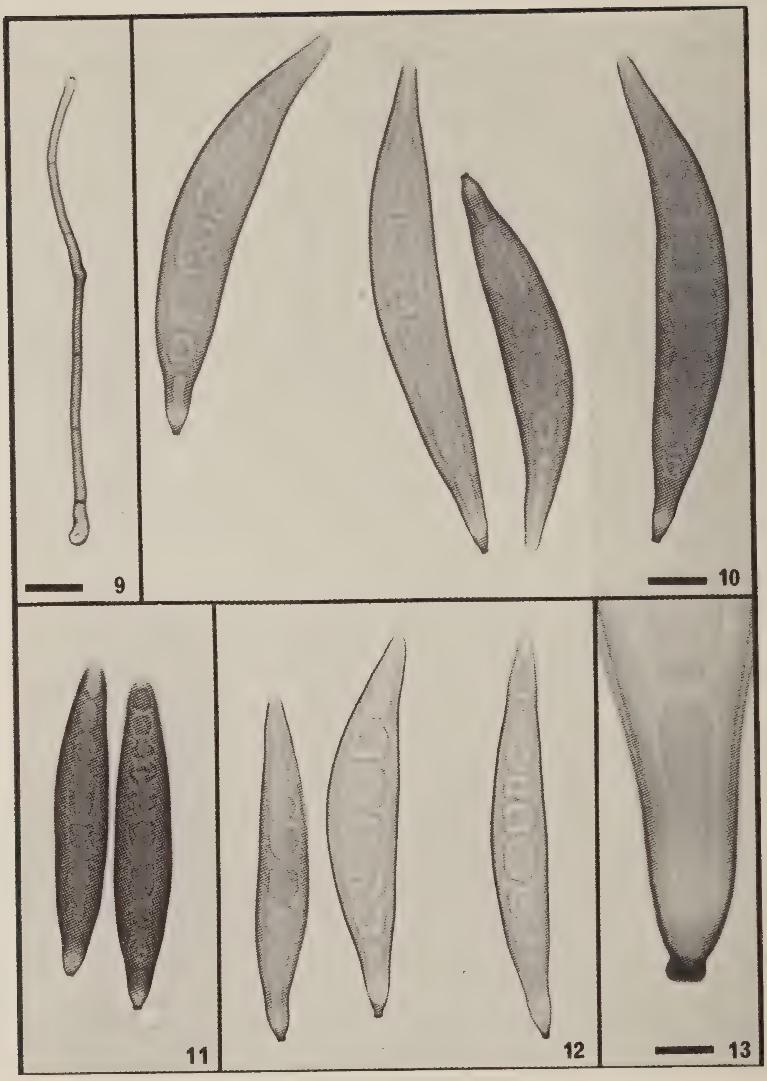
Exserohilum fusiforme Alcorn, sp. nov. (Figs 9-13)

Etym.: *fusiformis* (L) - fusiform, for conidial shape

Conidiophora singularia vel in turmis parvis aggregatis, simplicia, recta vel flexuosa, medio vel atro olivaceobrunnea, versus apicem pallidiora, cicatricata, ad cicatrices verruculosa, alibi laevia, multiseptata, 175-680 µm longa, ad basim saepe tumida 10-20 µm diam, prope basim 7.5-12.0 µm diam, ad apicem 5.5-9.0 µm diam. Conidia medio olivaceobrunnea, concoloria, fusiformia, recta vel parce curvata, saepe angustata infra septum basale, super hilum protrudens verruculosa, 3-11 plerumque 7 distoseptata, 80-193 x 15-24 µm.

Ex foliis *Echinochloae crus-galli* (L.) Beauv., Beaudesert, Queensland, Australia, 17 Mar. 1988, J.L. Alcorn 8822b, BRIP 16229 holotypus, IMI 335221 isotypus.

Conidiophores single or in small groups, simple, mid to dark olivaceous brown, paler towards apex, straight or flexuous, slightly



Figs 9-13. *Exserohilum fusiforme.* Fig. 9. Conidiophore. Figs 10-12. Conidia from WSA (fig. 10), PDA (fig. 11), infected leaves of *Echinochloa crus-galli* incubated in moist chamber (fig. 12). Fig. 13. Hilum. Bar (fig. 9) = 40 μm; (fig. 10) = 20 μm, figs 10-12; (fig. 13) = 5 μm.

geniculate at scars, multiseptate, 175-680 µm high, basal cell often swollen to 10-20 µm diam, 7.5-12.0 µm diam just above the swollen base and 5.5-9.0 µm at the apex, conidiogenous nodes 58-145 µm apart, verruculose. Conidia mid olivaceous brown, concolorous, fusiform, straight or usually moderately curved, often narrowed from basal septum to hilum, 80-193 x 15-24 µm, (3-)6-9(-11) septate, commonly 7-septate, verruculose just above the protruding hilum. Conidia formed on PDA are shorter, darker, and have less septa than those on WSA. Septum ontogeny is atypical; although the first septum is submedian (normal), the second septum forms in an approximately median position and the third is distal. Conidial germination is mono- or bipolar, with the apical germ tube axial and the basal semiaxial. The basal germ tube occasionally originates from a position some distance from the hilum and grows at a wider angle.

Of the species described from *Echinochloa*, *Exserohilum fusiforme* is most like *E. monoceras* (Drechsler) Leonard & Suggs and *E. echinochloae* Sivan. The former species has paler, less curved conidia which are often broader than those of *E. fusiforme* and on WSA the conidiophores of *E. monoceras* are much longer (Alcorn, 1988 b). Conidia of *E. echinochloae* are darker and broader than in *E. fusiforme* (Sivanesan, 1984; pers. obs.), the conidial hilum is more robust (2-3 x 3-4 µm compared with 1.5-2.0 x *ca* 2.8-3.0 µm), and conidiophores are wider at the tip (7-9 µm compared with 5.5-7.0 µm). Morphology in *E. fusiforme* also suggests comparison with *E. oryzicola* Sivan. (1984), described from rice in Colombia. Conidia of *E. oryzicola* are longer (up to 223 µm) than those of *E. fusiforme,* and on V-8A, SMA and WSA consistently have more septa, 7-13 (commonly 8-10; means 8.9-9.8) compared with 6-11 (commonly 7-9; means 7.7-8.3).

An additional characteristic indicating relationship between *E. fusiforme* and the two most similar species is roughening of the basal cell in the region adjacent to the hilum. Although not mentioned in the original descriptions of *E. oryzicola* and *E. echinochloae,* it is present in the specimens examined and is suggested by the published illustration of *E. echinochloae* (Sivanesan, 1984). No ascomata or protothecia developed in paired or selfed cultures of *E. oryzicola* and *E. fusiforme.* The latter species was virulently pathogenic to *Echinochloa crus-galli* when spray inoculated with conidia from V-8A, producing numerous small leaf lesions. In the same test rice (cv.

Starbonnet) developed a few small linear spots. The fungus was reisolated from both hosts.

Specimens and cultures examined: *Exserohilum fusiforme:* ex *Echinochloa crus-galli,* Beaudesert, Queensland, Australia, 17 Mar. 1988, J.L. Alcorn 8822b (BRIP 16229 holotype, IMI 335221 isotype). *Exserohilum oryzicola:* ex *Oryza sativa,* Colombia, 2 Nov. 1982, E.A. Urresta, IMI 273194 (BRIP 14577). *Exserohilum echinochloae:* ex *Echinochloa colona,* Bangladesh, 10 Apr. 1979, M.A. Miah, IMI 237838 (BRIP 16478).

Miscellaneous notes

Bipolaris palousensis Sprague, *Res. Stud. Wash. St. Univ.* 29: 77 (1961) (as '*palousense*').

No *Bipolaris* was found on the type specimen. There is a *Stenella*-like fungus present on the slide filed with the specimen, and the same species was found on a necrotic portion of leaf (some leaf lesions bear immersed immature ascomata, but no hyphomycete). Conidia taken from the host are cylindrical, yellowish-brown, straight or curved, cicatrized at one or both ends, 15-63 x 5.0-9.5 µm, 1-7 transversely septate with the septa commonly accentuated. Conidia on the slide with the specimen are 15-45 x 5-9 µm, (1-)3(-5) septate, and this is probably the fungus described by Sprague (1961) as *B. palousensis* ('spores yellowish, cylindrical, mostly triseptate, 20-58 x 5-7.3 µ').

Specimen examined: *Juncus ensifolius* Wiks., nr Colton, Whitman County, Washington, U.S.A., R. Sprague, C.G. Shaw & class, 18 May 1948, WSP 46818 (formerly 3925), holotype.

Cochliobolus sporoboli Castellani, *Mycopath. Mycol. appl.* 6: 56 (1951).

Sivanesan (1987) reported that a specimen could not be located. However in 1977, through the courtesy of Prof. Castellani, one of the collections originally cited was sent to me on loan. As indicated in the description (Castellani, 1951) there is a species of *Bipolaris* present on the specimen in association with the teleomorph. Conidia are cylindric-ellipsoid, straight, mid-brown, 32-50 x 10-15 µm, 3 or 4 septate, with a slightly protruding hilum *ca* 2.5 µm diam. A germinated conidium has a semi-axial basal germ-tube displacing

the hilum slightly. It is not possible to suggest a specific identity for this anamorph.
Specimen examined: on *Sporobolus affinis,* near Asmara, Erythrea, E. Africa, 12 Aug. 1914, I. Baldrati (ex herb. Istituto Agronomico per l'Oltremare, Florence; slides as BRIP 6482)

Helminthosporium atypicum K.S. Deshpande & K.B. Deshpande, *Sydowia* 20: 42 (1968).

The type specimen was not available to Sivanesan (1987), who suggested resemblance to *Bipolaris multiformis* (Jooste) Alcorn. A culture deposited in ATCC by the authors of the name is very similar to *B. sorokiniana* (Sacc.) Shoem..

Culture examined: ex *Triticum aestivum* L. leaf, Ajantha, India, Dec. 1963, K.S. & K.B. Deshpande (ATCC 18954, BRIP 12374).

Drechslera patereae Carranza, *Revta Fac. Agron. Univ. nac. La Plata* 59: 66 (1983).

This species was described from grains of durum wheat (*Triticum durum* Desf.) in Argentina. A culture authentic for the name is not distinguishable from *Bipolaris hawaiiensis* (M.B. Ellis) Uchida & Aragaki, although pairings with tester strains of *Cochliobolus hawaiiensis* Alcorn resulted only in the formation of cylindrical black stromata.

Culture examined: ex *Triticum durum,* Argentina, comm. 8 May 1987, M.R. Carranza *s.n.* (BRIP 14836).

Curators at ATCC, BPI, CBS, IMI, ITCC and WSP generously supplied specimens and/or cultures used in this study, as did E. Castellani, M.R. Carranza, R.D. Davis, H. Iliescu, J.J. Muchovej, A.Y. Rossman and D.L. Strider. D.H. Gowanlock provided the scanning electron micrographs.

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MYCOTAXON

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PORE FUNGI OF COSTA RICA 1/

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A large number of pore fungi have been collected in Costa Rica by several scientists since the beginning of the century. A first list was published by J. Carranza and J.A. Saenz (1984) which included some specimens collected by the authors and by others.

This paper will represent the first part of a more comprehensive report of the specimens collected up to date and will give an idea of the diversity present in the country.

The specimens listed are deposited in the Herbarium of the School of Biology, University of Costa Rica (USJ), the Herbarium of the USDA at Beltsville, Maryland (BPI), the Herbarium of the National Museum, Costa Rica (CR), or cited by other authors (Covington, 1980; Lowe, 1963; 1966; 1976; Murrill, 1915; Sydow, 1925).

Unless otherwise stated, the descriptions of the specimens agree with the ones given by Furtado (1981), Gilbertson & Ryvarden (1986; 1987), and Ryvarden & Johansen (1980).

MATERIALS AND METHODS

Free hand sections were prepared from each specimen and mounted in 3% KOH to which a drop of aqueous phloxine was added, and in Melzer´s reagent. Observations were done under a light microscope. All drawings of microscopic characters were made with the use of a camera lucida.

1/. This research was supported by Vicerrectoría de Investigación (Project 111-79-006) University of Costa Rica and CONICIT (Travel Grant to visit National Fungus Collection, Beltsville, Maryland).

Specimens are listed in alphabetical order. Herbarium abbreviations are from Holmgren et al. (1981). Those species preceded by an asterisk (*) are new records for the country.

LIST OF FUNGI

Corticiaceae

*__Gloeoporus dichrous__ (Fr.) Bres., Ann. Mycol. 14:230. 1916.
Polyporus dichrous Fr., Syst. Mycol. 1:364. 1821.

Voucher specimen examined: Santa Maria de Dota, San Jose, JCM 102-87 (USJ 22991); one collection done by Brenes in 1920 and deposited at BPI (207578). (Altitudinal distribution: 2021 m).
Type of rot: White rot.
Substrata: On hardwood and softwood trees.
Distribution: North, Central and South America; Africa.

Gloeoporus thelephoroides (Hook.) G.H. Cunn., Polyp. New Zealand p.111. 1965.
Gloeoporus conchoides. Mont., Ann. Sci. Nat. Ser. 2 Vol. 17:126. 1842.

Voucher specimens examined: Golfito, Puntarenas, JCM 12-80 (USJ 21300); Finca La Florencia,Turrialba, Cartago, JCM 28-81, (USJ 21504); Parque Nac. Corcovado, Puntarenas, S. Hernandez (USJ 28040); Atenas, Alajuela, JCM 21-85 (USJ 22266); Monteverde, Puntarenas, JCM 145-80 (USJ 21517). (Altitudinal distribution: 5-1500 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Africa.

Grammothele fuligo (Berk. & Br.) Ryv., Trans. Br. Mycol. Soc. 73:15. 1979.
Polyporus fuligo Berk. & Br., J.Linn. Soc. Bot. 14:53. 1875.

Voucher specimens examined: Finca La Selva, Sarapiqui,

Heredia, on palm, JCM 157-86 (USJ 22533); Finca La Selva, Sarapiqui, Heredia, C. Ovrebo 2239 (USJ 22979). (Altitudinal distribution: 37 m).
Type of rot: White rot.
Substrata: Monocotyledons (bamboo, palms).
Distribution: Central America; Africa; Asia.

Fistulinaceae

Fistulina hepatica Schaeff.: Fr., Syst. Mycol. 1:396. 1821.

Voucher specimens examined: Cerca del Volcan Irazu, Cartago, J.A. Saenz 2345 (USJ 21635); Patillos de Rancho Redondo, M. Boza, V.Lizano and M.Nassar, 2462 (USJ 21800). (Altitudinal distribution: 2080 - 2196 m).
Type of rot: Brown rot.
Substrata: On hardwood trees (**Quercus** sp.).
Distribution: North and Central America; Europe.

Fistulina radicata Schw., Schr. Nat. Geo. Leipzig 1:100. 1822.
Fistulina pallida Berk. & Rav., Grevillea 1:71. 1872.

Comments: There are only two collections at BPI (244153 and 244154) done by C. W. Dodge 5298 and 5323, on Retes, El Alto de Cabeza de Vaca & Chino, Cartago in 1929. (Altitudinal distribution: 2080 m).
Type of rot: Unknown.
Substrata: On hardwood trees.
Distribution: North, Central and South America.

Ganodermataceae

Amauroderma boleticeum (Pat. & Gail.) Torr., Brotéria Bot. 18:132. 1920.
Polyporus boleticeus Pat. & Gail., Bull. Soc. Mycol. Fr. 4: 29. 1888.

Comments: There are some differences in regards to the microscopic characters described by Furtado. The basidiospores in the Costa Rican specimens are slightly larger, viz. 8.8-12.8 x 6.4-10.4 um (Furtado: 7.0-10.0 x

7.0-9.0 um); basidia: 24.8-31.2 x 9.6-12.8 um (not observed by Furtado) (Fig.1).
Voucher specimens examined: La Selva Biological Station, Sarapiqui, Heredia, C. Ovrebo 2182 (USJ 27534) and C.Ovrebo 2761 (USJ 28160). (Altitudinal distribution: 37 m).
Distribution: Central and South America.

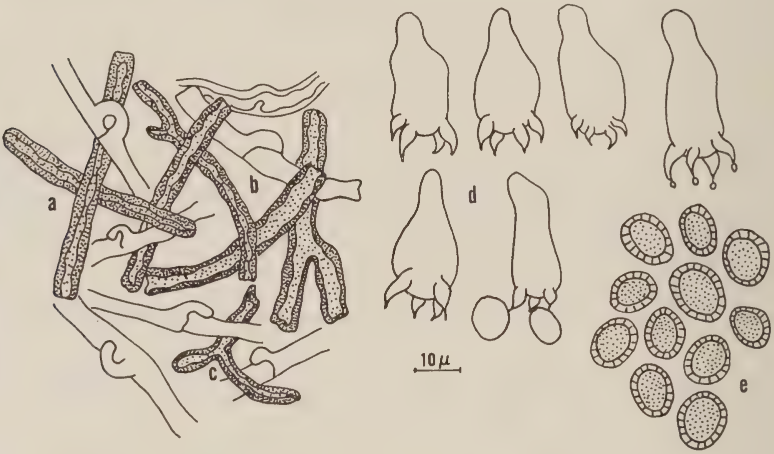

Fig. 1. **Amauroderma boleticeum** (USJ 27534). a, skeletal hyphae; b, generative hyphae; c, binding hyphae; d, basidia; e, basidiospores.

Amauroderma longipes (Lév.) Torr., Brotéria Bot. 18:135. 1920.
Polyporus longipes Lév., Ann. Sci. Nat. Bot. III, 5:124. 1846.

Comments: There is only one collection done by C.W. Dodge et al. 5658 (BPI 237124) in Limón, near Siquirres River and cited by Furtado (1981). (Altitudinal distribution: 70-170 m).
Distribution: Central and South America; Africa; Asia.

Amauroderma praetervisum (Pat.) Torr., Brotéria Bot. 18:131. 1920.

Ganoderma praetervisum Pat., Bull. Soc. Mycol. Fr. 5:78. 1889.

Comments: There is only one collection at the New York Botanical Garden 4820 ex-Ellis Herb. Collector unknown and described by Furtado (1981).
Distribution: Central and South America; Caribbean Islands.

Amauroderma schomburgkii (Mont. & Berk.) Torr., Brotéria Bot. 18. 140. 1920.
Polyporus schomburgkii Mont. & Berk., Lond. J. Bot. 3:331. 1844.

Comments: Macroscopic and microscopic characters agree with Furtado descriptions. Skeletal hyphae up to 8.8 um; binding hyphae 3.2 um; generative hyphae not seen; basidiospores 7.2-9.6 x 8.8-10.4 um; basidia not observed (Fig.2).
Voucher specimens examined: Puntarenas, near Sandoval River Jungle, C.W. Dodge (BPI 237192); Forest Reserve opposite to Esquinas Experimental Station, G.W. Martin & A.L. Welden 8241 (SP 97638 ex-NY); Carara Reserve, Puntarenas, JCM 86-87 (USJ 27909). (Altitudinal distribution: sea level-7 m).
Distribution: Central and South America; Africa; Caribbean Islands.

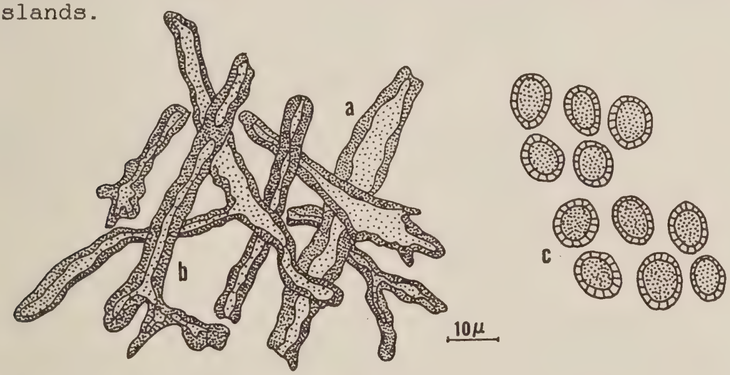

Fig. 2. **Amauroderma schomburgkii** (USJ 27909). a, skeletal hyphae; b, binding hyphae; c, basidiospores.

Amauroderma sprucei (Pat.) Torr., Brotéria Bot. 18:121. 1920.
Polyporus sprucei (Pat.) Lloyd, Mycol. Writ. (Synop. Stip. Polyp.) 3:111. 1912.

Comments: There is only one collection at BPI (237266), collected in Castilla, Limon by F. Nevermann and described by Furtado.
Distribution: Central and South America; Caribbean Islands.

Ganoderma applanatum (Pers.) Pat., Soc. Mycol. France Bull. 5:67. 1889.
Polyporus applanatus (Pers.) Wallr., Flora Crypt. Germ. 4:591. 1833.

Voucher specimens examined: Monteverde, Puntarenas, JCM 47-80, J.A. Saenz (USJ 21284); Ojo de Agua, El Empalme, San Jose, JCM 131-79 (USJ 21297); Bosque de La Hoja, Heredia, JCM 68-86 (USJ 22821); Isla del Coco, Puntarenas,G. Herrera, JCM 24-81 (USJ 21277) . (Altitudinal distribution: sea level-1853 m).
Type of rot: White rot of living and dead trees.
Substrata: On hardwood and softwood trees.
Distribution: Cosmopolitan.

Ganoderma australe (Fr.) Pat. Bull. Soc. Mycol. Fr. 5:67. 1889.
Polyporus australis Fr. Syst. Mycol. 1, 1821.

Voucher specimen examined: Monteverde, Puntarenas, L.D. Gomez & R. Alfaro 24946 (USJ 27613).(Altitudinal distribution: 1330-1900 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Cosmopolitan.

Ganoderma coffeatum (Berk.) Furt., Persoonia 4(4):383. 1967.
Polyporus coffeatus Berk., Ann. Mag. Nat. Hist. 3:385. 1839.

Comments: Basidiospores yellowish-brown, echinulate, truncate, 8.0-9.0 x 6.0-5.0 um.
Voucher specimens examined: Palo Verde, Guanacaste, L.D.

Gomez 24276 (USJ 22804); Isla San Lucas, Puntarenas, C. Garcia, JCM 279-86 (USJ 28026); Sn. Antonio de Nicoya, Guanacaste, M. Valerio 97 (BPI 235876).(Altitudinal distribution: sea level-100 m).
Type of rot: Unknown (white rot ?).
Substrata: On hardwood trees.
Distribution: Central and South America; Caribbean Islands.

Ganoderma colossum (Fr.) C.F. Baker, V Cent. Fungi Malay. No. 425. 1918.
Polyporus colossus Fr., Nov. Symb. p. 56, 1851.

Comments: Murrill (1915) cited some specimens collected in Costa Rica, but no duplicates are deposited at USJ. One collection done by Danielson 173 in 1928 and deposited at BPI (206112).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Africa.

Ganoderma lucidum (W. Curt.: Fr.) Karst., Rev. Mycol. 3(9):17. 1881.
Polyporus lucidus W. Curt.: Fr., Syst. Mycol. 1:353. 1821.

Voucher specimens examined: Sixaola, Limon, A. Conejo, JCM 32-88 (USJ 28075); Alto de Lagunilla, Santa Cruz, Guanacaste, JCM 138-86 (USJ 22758); Parque Nacional de Santa Rosa, Guanacaste, L. Umana 1-89 (USJ 28199); Jardin de Dota, San Jose, JCM 16-85 (USJ 22757). (Altitudinal distribution: 37-1500 m).
Type of rot: White rot.
Substrata: On hardwood and softwood trees.
Distribution: North , Central and South America; Africa; Europe; Asia.

Ganoderma neurosporum Furtado, Persoonia 4:386. 1967.

Comments: Listed by Furtado (1967). One specimen at BPI, collected by Dodge et al. 5668 (?) No duplicates at USJ.

Ganoderna nutans (Fr.) Pat. , Bull. Soc. Mycol. Fr. 5:68. 1889.

Amauroderma nutans (Fr.) Murr., North Am. Fl. 9:117. 1908.

Comments: Listed by Murrill (1915) but no duplicates at USJ. There are not authentic specimens of this species and the name should be dropped from consideration (Ryvarden, pers. comm., 1990).

Hymenochaetaceae

*__Aurificaria luteo-umbrina__ (Romell) Reid, Kew Bull. 17:279. 1963.
Phaeoporus luteo-umbrinus Romell, K. Svenska Vetensk. Akad. Handl. 26, No. 16:27. 1901.

Comments: Basidiospores yellowish brown to greenish brown or olivaceous in KOH, sub-globose to globose, smooth walled, 3.2-5.0 x 3.5-5.6 um; hyphae 3.2-7.0 um, thick walled, simple septate, brown (Fig. 3).
Voucher specimens examined: Monteverde, Puntarenas, JCM 217-87 (USJ 27950); Reserva Carara, Puntarenas, JCM 114-87 (USJ 27530); Monteverde, Puntarenas, JCM 153-87 (USJ 28032). (Altitudinal distribution: 7-1330 m).
Type of rot: White rot.
Subtrata: On hardwood trees.
Distribution: North, Central , and South America; Australia.

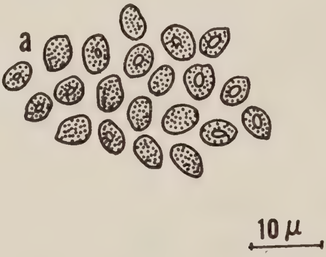

Fig. 3. **Aurificaria luteo-umbrina** (USJ 27530). a, basidiospores.

*__Coltricia cinnamomea__ (Pers.) Murr., Bull. Torr. Bot. Cl. 31:343. 1904.
Polyporus cinnamomeus Pers., Mycol. Europ. 2:41. 1825.

Voucher specimens examined: Monteverde, Puntarenas, JCM 147-87 (USJ 27912); Frailes, San Jose, JCM 1-79 (USJ 21034). (Altitudinal distribution: 1330-2200 m).
Substrata: On the ground or from buried wood (hardwood).
Distribution: North and Central America; Africa; Asia; Australia; Europe.

Coltricia perennis (Fr.) Murr., J. Mycol. 9:91. 1903.
Boletus perennis L., Sp. Plant., p. 1177. 1753. **Polyporus perennis** Fr., Syst. Mycol. 1:350. 1821.

Comments: For a more detailed description see Carranza & Saenz (1984).

*__Coltricia spathulata__ (Hook.) Murr., North Am. Fl. 9:93. 1908.
Polyporus spathulatus Hook. in Kunth, C.S. Synopsis Plant. 1:9. 1822.

Voucher specimen examined: El Eden, Santa Marta, Buenos Aires, Puntarenas, L.D. Gomez 22979 (USJ 22830). (Altitudinal distribution: 361 m).
Substrata: On the ground.
Distribution: North, Central and South America; Africa; Asia; New Guinea.

Cyclomyces iodinus (Mont.) Pat., Essai Tax. p. 98. 1900.
Polyporus iodinus Mont., Ann. Sci. Nat. Bot. 2, 16:108. 1841.

Comments: The specimens collected in Costa Rica are described by Carranza & Saenz (1984).

*__Cyclomyces tabacinus__ (Mont.) Pat., Essai Tax. p. 98. 1900. **Polyporus tabacinus** Mont., Ann. Sci. Nat. Ser. 3, Vol. 3:349. 1835.

Voucher specimens examined: Costa Rica, K. Danielson 159, 1928 (BPI 222349); Cocos Island, A. Stewart 1537, 1905 (BPI 222332); Chatham Bay, Cocos Island, P.D. Ashlock 22,

1964 (BPI 222319). (Altitudinal distribution: sea level-1300 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central and South America; Africa.

Inonotus fimbriatus Gomez & Ryv., Mycotaxon 23:291-292. 1985.

Comments: No duplicates at USJ.
Distribution: Costa Rica.

Inonotus fulvomelleus Murr., N. Amer. Flora 9, p. 86. 1908.
Polyporus fulvomelleus (Murr.) Sacc. & Trott.

Comments: Listed by Covington (1980). No duplicates at USJ. One collection done by Holm and Iltis in 1949, and deposited at BPI (214186).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central America; Caribbean Islands.

*__Inonotus pertenuis__ Murr., N. Amer. Flora 9, p. 86. 1908.

Comments: Basidiospores 4.0 x 2.5 um; setae 15.6-39.0 x 5.2-7.8 um.
Voucher specimens examined: Bosque de La Hoja, Heredia, JCM 49-79 (USJ 21312); Terron Colorado, Alajuela, JCM 69-81 (USJ 28028). (Altitudinal distribution: 65-1530 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central America.

Inonotus porrectus Murr., Tropical Polypores, p. 68. 1915.
Polyporus porrectus (Murr.) Sacc. & Trott., Syll. Fung. 25: 374. 1925.

Comments: Listed by Covington (1980). No duplicates at USJ.
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Caribbean Islands.

Polyporaceae

***Abortiporus biennis** (Bull.: Fr.) Sing., Mycologia 36:68. 1944.
Heteroporus biennis (Fr.) Laz., Rev. Real. Acad. Cienc. Exac. Fisc. Nat. Madrid 15:120. 1916.

Comments: There is only one collection made by C.W. Dodge in San Jose (BPI 204179). (Altitudinal distribution: 1000 - 1100 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Europe; Asia; Australia.

Anomoporia myceliosa (Peck) Pouz., Ceska Mykol. 20:172. 1966.
Poria myceliosa Peck, N.Y. State Mus. Bull. 54:952. 1902.

Comments: The specimens collected in Costa Rica are described by Lowe (1966).
Voucher specimens examined: Uvita, Heredia, on **Cupressus sp.** J.L. Lowe 13108 (USJ 9796); Tarbaca, San Jose, on hardwood, J.L. Lowe 13335 (USJ 9795); Jardin, San Jose, J.L. Lowe 13394 (USJ 9794). (Altitudinal distribution: 50-2150 m).
Type of rot: White rot.
Substrata: On softwood (**Cupressus sp.**) and hardwood trees.
Distribution: North and Central America; Europe; Asia.

***Antrodia albida** (Fr.) Donk., Persoonia 4:339. 1966.
Trametes sepium Berk., Lond. J. Bot. 6:322. 1847.

Comments: Basidiospores cylindrical to oblong ellipsoid, hyaline, thin-walled, none amyloid, 8.0-10.0 x 3.5-4.0 um.
Voucher specimen examined: Bosque de la Hoja, Heredia, on **Cupressus sp.**, JCM 69-86 (USJ 22542). (Altitudinal distribution: 1200-1530 m).
Type of rot: Brown rot.
Substrata: On softwood (**Cupressus sp.**) and hardwood trees.
Distribution: Cosmopolitan.

***Antrodia malicola** (Berk. & Curt.) Donk., Persoonia 4:340. 1966.
Trametes malicola Berk. & Curt., Acad. Nat. Sci. Phila. J. II, 3:209. 1856.

Comments: Basidiospores ellipsoid, hyaline, smooth-walled, 7.2-10.0 x 2.4-3.2 um; generative hyphae 1.6-2.4 um, skeletal hyphae 2.4-4.8 um; basidia 12.0 x 4.0 um (Fig. 4).
Voucher specimen examined: Monte de la Cruz, Heredia, L.D. Gomez 24186 (USJ 22890). (Altitudinal distribution: 1200-1800 m).
Type of rot: Brown rot.
Substrata: On hardwood trees.
Distribution: Cosmopolitan.

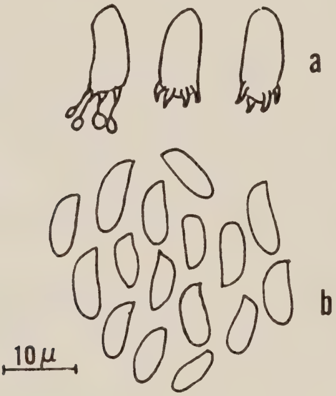

Fig. 4. **Antrodia malicola** (USJ 22890). a, basidia; b, basidiospores.

Antrodia radiculosa (Pk.) Gilbn. & Ryv., Mycotaxon 22:363. 1985.
Poria radiculosa (Pk.) Sacc., Syll. Fung. 6:314. 1888.

Comments: The specimens collected in Costa Rica are described by Lowe (1966) and Gilbertson & Ryvarden (1986).
Voucher specimen examined: Itiquis, Alajuela, J.L. Lowe 13501 (USJ 9800). (Altitudinal distribution: 1357 m).
Type of rot: Brown rot.
Substrata: On softwood and hardwood trees.

Distribution: North and Central America; Caribbean Islands.

*__Antrodia vaillantii__ (Fr.) Ryv., Norw. J. Bot. 20:8. 1973.
Poria vaillantii (DC.: Fr.) Cke., Grevillea 14:112. 1886.

Comments: Basidiospores oblong, broadly ellipsoid, hyaline, smooth-walled, 4.0-6.0 x 3.2-4.0 um; basidia 12.0-16.8 x 5.6-7.2 um (Fig. 5).
Voucher specimen examined: Uvita, Heredia, J.L. Lowe 13100 (USJ 9802). (Altitudinal distribution: 1900 m).
Type of rot: Brown rot.
Substrata: On softwood trees.
Distribution: North and Central America; Europe; Africa; Asia.

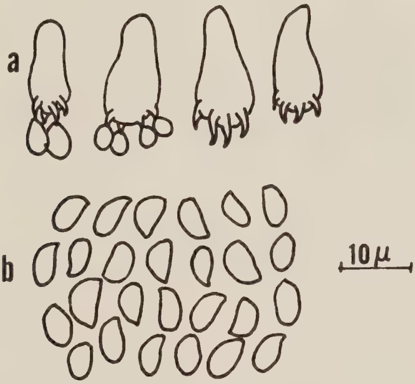

Fig. 5. **Antrodia vaillantii** (USJ 9802). a, basidia; b, basidiospores.

*__Antrodiella semisupina__ (Berk. & Curt.) Ryv., Prelim. Polyp. Fl. East Africa, p. 261. 1980.
Polyporus semisupinus Berk. & Curt., Grevillea 1:50. 1872.

Comments: Basidiospores ellipsoid, hyaline, smooth-walled, 2.4-3.2 x 1.6-2.0 um; generative hyphae nodose-septate, 2.4-3.0 um ; skeletal hyphae up to 4.8 um.
Voucher specimen examined: Rio Segundo, Alajuela, L.D. Gomez 24229 (USJ 22870). (Altitudinal distribution:

600-900 m).
Type of rot: White rot.
Substrata: On hardwood, rarely on softwood trees.
Distribution: North and Central America; Africa; Europe.

Bjerkandera adusta (Willd.: Fr.) Karst., Medd. Soc. Fauna Fl. Fenn. 5:38. 1879.
Polyporus adustus Willd. : Fr., Syst. Mycol. 1:363. 1821.

Comments: The specimens collected in Costa Rica are described by Carranza & Saenz (1984). (Altitudinal distribution: 120-2200 m).

*__Bjerkandera fumosa__ (Pers.: Fr.) Karst., Medd. Soc. Fauna Fl. Fenn. 5:38. 1879.
Polyporus fumosus Pers.: Fr., Syst. Mycol. 1:367. 1821.

Comments: Only one specimen collected in Cartago by C.W. Dodge and W.S. Thomas in 1929 (BPI 214360).
Type of rot: White rot of sapwood of hardwood.
Substrata: On hardwood trees.
Distribution: North , Central and South America; Europe; Asia; Africa; Australia.

*__Ceriporia alachuana__ (Murr.) Hallenb. Iran. J. Pl. Path. 15: 14. 1979.
Poria alachuana Murr., Bull. Torrey Bot. Club 65:659. 1938.

Comments: Basidiospores 3.2-4.0 x 2.4 um, hyaline, smooth-walled; hyphae 4.8 um, simple septate.
Voucher specimen examined: La Cuesta Mansion, Nicoya, Guanacaste., on hardwood JCM 291-86 (USJ 28272). (Altitudinal distribution: 87 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America.

Ceriporia purpurea (Fr.) Donk, Konn. Nederl. Akad. Wetensch. Amst. Proc. Ser. c. 74, No. 1:28. 1971.
Polyporus purpurea (Fr.) Cke., Grevillea 14:112. 1886.

Comments: The specimens collected in Costa Rica are described by Carranza & Saenz (1984).

*__Ceriporia reticulata__ (Pers.: Fr.) Dom., Acta Soc. Bot. Pol. 32:732. 1963.
Poria reticulata (Pers.: Fr.) Cke., Grevillea 14:114. 1886.

Voucher specimen examined: Sta. Clara, San Jose, on hardwood, J.L. Lowe 12993 (USJ 9798). (Altitudinal distribution: 900-1000 m).
Type of rot: White rot.
Substrata: On hardwood, rarely on softwood trees.
Distribution: North, Central and South America; Europe; Tunisia; Asia.

Ceriporia xylostromatoides (Berk.) Ryv. & Johan., Prelim. Polyp. Fl. East Afr., p. 276. 1980.
Polyporus xylostromatoides Berk., Lond. J. Bot. 2:637. 1843. **Poria xylostromatoides** (Berk.) Cke., Grevillea 14: 114. 1886.

Voucher specimens examined: Ciudad Colon, San Jose, on hardwood, J.L. Lowe 12995 (USJ 9781); Uvita, Heredia, on hardwood, J.L. Lowe 13258 (USJ 9778); Turrialba, Cartago, on hardwood, J.L. Lowe 13314 (USJ 9779); Alajuela, Alajuela, on hardwood, J.L. Lowe 13370 (USJ 9786). (Altitudinal distribution: 650-2000 m).
Type of rot: White rot.
Substrata: On hardwood and softwood trees.
Distribution: North, Central and South America; Africa; Caribbean Islands; India; Sri Lanka.

*__Cerrena meyenii__ (Kl.) Hansen, Nat. Hist. Rennel Isl. 3:129. 1960.
Polyporus meyenii Kl., Nova Acta Leop.-Carol. 19 Suppl. 1:239. 1845 (?).**Trametes obstinatus** Cke., Grevillea 12:17. 1883.

Comments: There are two sterile specimens collected in Costa Rica. One collected in San Antonio de Coronado, San Jose by L.D. Gomez 24211 (USJ 22878) and the other one collected in Turrialba by William Maxon 210, in 1906 (BPI 212998). (Altitudinal distribution: 646-1400 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central America; Africa.

***Cerrena unicolor** (Bull.: Fr.) Murr., J. Mycol. 9:91. 1903.
Daedalea unicolor Bull.: Fr., Syst. Mycol. 1:336. 1821.

Voucher specimen examined: San Gerardo de Dota, San Jose, L.D. Gomez 24246 (USJ 22874). (Altitudinal distribution: sea level-2000 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America; Europe; Asia; Africa.

Chaetoporellus latitans (Bourd. et Galz.) Bond. et Sing., Ann. Mycol. 39:50. 1941.
Poria latitans Bourd. et Galz., Bull. Soc. Mycol. France 41:226. 1925.

Voucher specimens examined: Jardin, Santa Maria de Dota, San Jose, J.L. Lowe 13388 (USJ 9806); Santo Domingo de San Mateo, Wn. Maxon 1906 (BPI 242453). (Altitudinal distribution: 1586-2100 m).
Type of rot: Uniform white rot.
Substrata: On hardwood and softwood trees.
Distribution: North and Central America; Asia; Europe.

Coriolopsis brunneo-leuca (Berk.) Ryv., Norw. J. Bot. 19:230. 1972.
Polyporus brunneo-leucus Berk., Lond. J. Bot. 5:4. 1846.

Comments: There is only one sterile specimen collected in Palmar Norte, Puntarenas by A.L. Welden 3399 in 1974 (TU 9038, USJ 21039). (Altitudinal distribution: 26 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central America; Africa.

Coriolopsis byrsina (Mont.) Ryv., Norw. J. Bot. 19:230. 1972.
Polyporus byrsinus Mont., Ann. Sci. Nat. 17:126. 1842.

Voucher specimens examined: Carara Reserve, Puntarenas, on hardwood, JCM 248-86 (USJ 27599); Santa Rosa, Guanacaste, on hardwood, JCM 165-79 (USJ 21044); Ciudad Colon, San Jose, on hardwood, JCM 159-79 (USJ 21045). (Altitudinal distribution: 7-900 m).

Type of rot: White rot.
Substrata: On hardwood trees **(Inga sp.)**
Distribution: North, Central and South America; Africa.

***Coriolopsis floccosa** (Jungh.) Ryv., Norw. J. Bot. 19:230. 1972.
Polyporus floccosus Jungh., Verh. Batav. Genootsch. 17:49. "1839" (print 1838).

Voucher specimens examined: Santa Rosa, Guanacaste, on hardwood, JCM 172-79 (USJ 21077); Santa Maria de Dota, San Jose, on hardwood, JCM 36-88 (USJ 27916); Monteverde, Puntarenas, on hardwood, JCM 167-87 (USJ 27553). (Altitudinal distribution: sea level-2100 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America; Africa.

Coriolopsis polyzona (Pers.) Ryv., Norw. J. Bot. 19 (3-4): 230. 1972.
Polyporus polyzonus Pers., Gaudichaud Voy. aut. Monde., Bot. p. 170. 1827.

Voucher specimens examined: Finca El Rodeo, Ciudad Colon, San Jose, on **Enterolobium cyclocarpum**, JCM 39-86 (USJ 22253); Cañas, Guanacaste, on hardwood, JCM 119-79 (USJ 21073); Limon, Limon, on hardwood, JCM 124-80 (USJ 21075); Orosi, Cartago, on hardwood, JCM 18-79 (USJ 21072). (Altitudinal distribution: sea level-1050 m).
Type of rot: White rot.
Substrata: On hardwood trees **(Enterolobium cyclocarpum; Gliricidia sepium; Hevea brasiliensis; Ochroma lagopus).**
Distribution: Central and South America; Africa; Caribbean Islands.

***Daedalea aethalodes** (Mont.) Rajsch., Can. J. Botany 64: 2130-2135. 1986.
Trametes aethalodes Mont., Ann. Sci. Nat. Ser. 4,5:370. 1857.

Comments: There is only one sterile specimen collected by R. Alfaro 60 (USJ 22903), in Cerro La Carpintera, Cartago. (Altitudinal distribution: 1500 m).
Type of rot: White rot.
Substrata: On hardwood trees.

Distribution: Central and South America.

Daedalea microsticta Cke., Grevillea 10:122. 1882.

Voucher specimen examined: Road to Volcan Poas, Alajuela, on hardwood, A.L. Welden 3182 (TU 7815; USJ 21139); Turrialba near Rio Reventazon, W.R. Maxon (BPI 254228); Puerto Viejo, Sarapiqui, Heredia, A. Raske 1614 (BPI 254286). (Altitudinal distribution: 30-1200 m).
Type of rot: Brown rot.
Substrata: On hardwood trees.
Distribution: Central America; Caribbean Islands.

***Daedalea quercina** Fr., Syst. Mycol. 1:333. 1821.

Voucher specimens examined: Finca cerca de Pension Flor Mar, Monteverde, Puntarenas, JCM 159-87 (USJ 27544); San Gerardo de Dota, San Jose, L.D. Gomez 24237 (USJ 22800); Reserva San Ramon, Alajuela, JCM 246-86 (USJ 22805); Cerro Platanar, San Carlos, Alajuela, S. Morse (JCM 216-86, USJ 22806). (Altitudinal distribution: 1057-2000 m).
Type of rot: Brown heart rot.
Substrata: On hardwood trees.
Distribution: North and Central America; Asia; Europe; Africa.

Datronia caperata (Berk.) Ryv., Mycotaxon 23:172. 1985.
Coriolopsis caperata (Berk.) Murr., N. Am. Fl. 9:77. 1908.

Voucher specimens examined: Ciudad Colon, San Jose, JCM 286-86 (USJ 27574), Finca Las Cruces, San Vito, JCM 196-86 (USJ 22753); Tilaran, Guanacaste, JCM 200-80 (USJ 27934). (Altitudinal distribution: sea level-1200 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Africa.

Datronia mollis (Sommerf.:Fr.) Donk. Persoonia 4:338. 1966.
Daedalea mollis Sommerf.:Fr., Elench. Fung. p.71. 1828.

Voucher specimen examined: Heredia, Heredia, L.D. Gomez 24361(USJ 22888). (Altitudinal distribution: 1100 m).
Type of rot: White rot.

Substrata: On hardwood trees.
Distribution: North and Central America.

Datronia scutellata (Schw.) Gilbn. & Ryv., Mycotaxon 22: 364. 1985.
Polyporus scutellatus Schw., Trans Am. Phil. Soc. II, 4: 157. 1832. **Fomitopsis scutellata** (Schw.) Bond. & Sing., Ann. Mycol. 39:55. 1941.

Only one collection done by Dodge & Goerger (9257) in 1936 and deposited at BPI (234659). No duplicates at USJ.
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America; Asia; Africa; Australia.

Datronia stereoides (Fr.) Ryv., Flora over Kjuker, p. 42. 1968.
Polyporus stereoides Fr., Syst. Mycol. 1:369. 1821.

Comments: Murrill (1915) mentioned one collection done in San Jose. No duplicates are deposited at USJ.
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America; Europe.

Diplomitoporus lenis (Karst.) Gilbn. & Ryv., Mycotaxon 22: 364. 1985.
Physisporus lenis Karst. in Rabenh. Wint. Fungi Eur. et Exeur. Excs. no. 3527. 1886.

Voucher specimens examined: La Virgen, Heredia, J.L. Lowe 13439 (USJ 22009); Navarro, San Jose, A.L. Welden 3018 (TU 8572, USJ 21985). (Altitudinal distribution: 260 m).
Type of rot: White rot.
Substrata: On softwood and hardwood trees.
Distribution: North and Central America; Caribbean Islands; Europe; Asia.

Earliella scabrosa (Pers.) Gilbn. & Ryv., Mycotaxon 22:364. 1985.
Polyporus scabrosus Pers. in Gaudich., Voy. aut. Monde p. 172. 1827.
Voucher specimens examined: Santa Rosa, Guanacaste, JCM

170-79 (USJ 22043); Ciudad Colon, San Jose, JCM 186-79 (USJ 22044); Monteverde, Puntarenas, JCM 212-86 (USJ 22722); Alto de Ochomogo, Cartago, JCM 31-79 (USJ 22048). (Altitudinal distribution: sea level-1500 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Africa; Caribbean Islands.

Echinochaete brachyporus (Mont.) Ryv., Bull. Jard. Bot. Nat. Belg. 48:101. 1978.
Polyporus brachyporus Mont., Ann. Sci. Nat. ser. 4, 1:131. 1854.

Voucher specimens examined: Costa Rica, K.A. Danielson 158, 1928 (BPI 212777); Upala, Alajuela, A. Conejo (JCM 1-89, USJ 28164). (Altitudinal distribution: 48 m).
Type of rot: White rot (?).
Substrata: On hardwood trees.
Distribution: Central America; Africa.

Echinoporia aculeifera (Berk. & Curt.) Ryv., Mycotaxon 19: 330. 1984.
Trametes aculeifera Berk. & Curt., J. Linn. Soc. Bot. 10: 319. 1868.

Only one collection done by Standley and Valerio in 1926 and deposited at BPI (245404). No duplicates at USJ.
Type of rot: Unknown.
Substrata: On hardwood trees.
Distribution: North, Central and South America.

Favolus paraguayensis Speg., An. Soc. Cient. Argent. 17:71. 1884.

Comments: There is one collection mentioned by Bommer and Rousseau (1896) cited by Covington (1980). No duplicates at USJ.

Flavodon flavus (Kl.) Ryv., Norw. J. Bot. 20:3. 1973.
Irpex flavus Kl., Linnaea 8:488. 1833.

Voucher specimen examined: Palo Verde, Guanacaste, JCM 46-88 (USJ 28274). (Altitudinal distribution: 80-200 m).

Type of rot: Unknown.
Substrata: On hardwood trees.
Distribution: Pantropical.

Fomes auberianus (Mont.) Murr., Torrey Bot. Club Bull. 32: 491. 1905.
Polyporus auberianus Mont. in de la Sagra Plant Cell. Cuba p. 399. 1842.

Two collections done by Maxon (207-613) in 1906 and deposited at BPI (228254-228253). No duplicates at USJ.

Fomes fasciatus (Sw.: Fr.) Cke., Grevillea 14:21. 1885.
Polyporus fasciatus Sw.: Fr., Syst. Mycol. 1:3373. 1821.
Fomes marmoratus (Berk. et Curt.) Cke., Grevillea 14:18. 1885. **Fomes sclerodermeus** (Lev.) Cke., Grevillea 14:18. 1885.

Voucher specimens examined: Upper slopes of Poas Volcano, Alajuela, D.E. Stone (TU 522; USJ 21201); Vara Blanca, Heredia, A.L. Welden (TU 7022; USJ 21233); Cerca del puente La Vieja, Zarcero, Alajuela, JCM 236-80 (USJ 28201). (Altitudinal distribution: 1440-1800 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America.

Fomitella supina (Swartz : Fr.) Murr., Bull. Torrey Bot. Club 32:365. 1905.
Fomitopsis supina (Fr.) Ryv., Bull. Jard. Bot. Nat. Belg. 47:102. 1978. **Polyporus supinus** Swartz : Fr., Syst. Mycol. 1:376. 1821.

Voucher specimens examined: San Ramon, Alajuela, A.L. Welden 3240 (TU 9045, USJ 27609); San Ramon, Alajuela, A.L. Welden 3231 (USJ 21293); Rio Segundo, Alajuela, L.D. Gomez 24223 (USJ 22904); Ciudad Colon, San Jose, JCM 292-80 (USJ 27535). (Altitudinal distribution: 840-1057 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; West Indies; Africa.

Fomitopsis cupreo-rosea (Berk.) Carranza & Gilbn., Mycotaxon 2:476. 1986.
Trametes cupreo-rosea (Berk.) Lloyd, Mycol. Writ. 4 (Synop. **Fomes**) 226. 1915.

Comments: For a more detailed description see Carranza-Morse & Gilbertson (1986).

Fomitopsis dochmia (Berk. & Br.) Ryv., Norw. J. Bot. 19: 231. 1972.
Fomes dochmius (Berk. & Br.) Cke., Grevillea 14:17. 1985.

Comments: For a more detailed description see Carranza-Morse & Gilbertson (1986).

Fomitopsis feei (Fr.) Kreisel, Univ. Habana (Cuba), ser. 4, Cienc. Biol. No. 16:83. 1971.
Trametes feei (Fr.) Pat., Essai Taxon. p. 92. 1900.

Comments: A more detailed description by Carranza-Morse & Gilbertson (1986).

Fomitopsis ligneus (Berk.) Ryv., Norw. J. Bot. 19:231. 1972.
Fomes ligneus (Berk.) Cke., Grevillea 13:119. 1885.

Comments: Covington (1980) mentioned one collection done by Murrill in Costa Rica. No duplicates at USJ.
Type of rot: Unknown.
Substrata: On hardwood trees.
Distribution: Central America; Caribbean Islands.

*__Fomitopsis nivosa__ (Berk.) Gilbn. & Ryv., North American Polypores, p. 275. 1986.
Trametes nivosa (Berk.) Murr., North Am. Fl. 9:42. 1907.
Polyporus nivosus Berk., Hook. J. Bot. 1:196. 1856.

Voucher specimen examined: Herediá, Heredia, L.D. Gomez 24365 (USJ 22892). (Altitudinal distribution: 1100 m).
One collection done by Standley (42970) in 1925 and deposited at BPI (247420, 247425). No duplicate at USJ.
Type of rot: Brown rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Africa.

Fuscocerrena portoricensis (Fr.) Ryv., Trans. Br. Mycol. Soc. 79:280. 1982.
Polyporus portoricensis Fr., Elench. Fung. 1:115. 1828

Voucher specimens examined: Pension Flor Mar, Monteverde, Puntarenas, JCM 168-87 (USJ 27551); Jardin, Santa María. de Dota, San Jose, J.L. Lowe 13402 (USJ 21137); Cariblanco, Heredia, J.L. Lowe 12974 (USJ 21134); Cascajal de Coronado, San Jose, JCM 230-86 (USJ 22750). (Altitudinal distribution: 1009-2100 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America.

Gloeophyllum mexicanum (Mont.) Ryv., Nord. J. Bot. 2:79. 1982.
Daedalea berkleyi Sacc., Syll. Fung. 6:381. 1888.

Only one sterile collection done by Sigers in 1922 and deposited at BPI (252656). No duplicates at USJ.
Type of rot: Brown rot.
Substrata: On softwood trees.
Distribution: North and Central America.

Gloeophyllum striatum (Sw. : Fr.) Murr., Torrey Bot. Club Bull. 32:370. 1905.
Daedalea striata Sw.: Fr., Syst. Mycol. 1:334. 1821.

Voucher specimens examined: Bijagua, Upala, Alajuela, JCM 266-86 (USJ 27593); Palo Verde, Guanacaste, JCM 10-88 (USJ 28214); Santo Domingo, Heredia, L.D. Gomez 24339 (USJ 22798); Ciudad Colon, Finca El Rodeo, San Jose, JCM 298-80 (USJ 21325); Palmar, Puntarenas, JCM 4-80 (USJ 21327). (Altitudinal distribution: 26-1000 m).
Type of rot: Brown rot.
Substrata: On hardwood **(Calycophyllum candidissimum)**, and softwood trees.
Distribution: North and Central America; Africa; Caribbean Islands.

Hexagonia hydnoides (Fr.: Sw.) M. Fidalgo, Mem. New York Bot. Gard. 17 (2):35-108. 1968.
Polyporus hydnoides Fr., Syst. Mycol. 1:362. 1821.

Comments: A more detailed description by Carranza y Saenz (1984).

Hexagonia papyracea Berk., Ann. Mag. Nat. Hist. 10:379. 1843.
Hexagonia variegata Berk., Ibid. Ser. 2, Vol. 9:196. 1852.

Voucher specimens examined: Parque Nac. Volcan Rincon de la Vieja, Guanacaste, R. Alfaro 42 (USJ 22835); Abangares, Guanacaste, JCM 115-79 (USJ 21155); Parque Nac. Santa Rosa, Guanacaste, JCM 168-79 (USJ 21157); Rio Segundo, Alajuela, L.D. Gomez 24227 (USJ 22788). (Altitudinal distribution: 29-1500 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Caribbean Islands.

Hexagonia tenuis (Hook.) Fr., Epicr. Syst. Mycol. p. 498. 1838.
Boletus tenuis Hook., in Kunth. Syn. Pl. 1:10. 1822.

Voucher specimens examined: Parque Nac. Barra Honda, C. Garcia, JCM 243-86 (USJ 22782); Alto de las Palomas, Santa Ana, San Jose, JCM 16-86 (USJ 22250); Naranjo, Alajuela, JCM 104-86 (USJ 22317); San Antonio de Belen, Heredia, JCM 9-81 (USJ 21153). (Altitudinal distribution: sea level-1330 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central America; Africa.

Hexagonia unicolor Fr.

Comments: Listed by Bommer and Rousseau (1896) cited by Covington (1980). No duplicates at USJ. There are not authentic specimens of this species and the name should be dropped from consideration (Ryvarden, pers. comm., 1990).

***Hydnopolyporus fimbriatus** (Fr.) Reid, Persoonia 2:151. 1962.
Polyporus fimbriatus Fr., Linnaea 5:520. 1830.

Voucher specimen examined: Reserva Biologica Isla del Caño, Puntarenas, R. Alfaro 222 (USJ 27632). (Altitudinal distribution: sea level).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America.

Incrustoporia carneola (Bres.) Ryv., Norw. J. Bot. 19(3-4): 232. 1972.
Poria carneola Bres., Hedwigia 35:282. 1896.

Comments: Cited by Lowe (1966). No duplicates at USJ.
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Africa.

Irpex lacteus (Fr.: Fr.) Fr., Elench. Fung., p. 145. 1828.
Sistotrema lacteum Fr., Obs. Mycol. 2:226. 1818.
Polyporus tulipiferae (Schw.) Overh., Wash. Univ. Studies 3, 1:29. 1915.

Voucher specimen examined: Finca El Rodeo, Ciudad Colon, San Jose, JCM 42-86 (USJ 22759). (Altitudinal distribution: 840 m).
Type of rot: White rot.
Substrata: On hardwood **(Bursera simarouba)** and softwood trees.
Distribution: North and Central America; Africa; Europe.

*__Ischnoderma resinosum__ (Fr.) Karst., Soc. Fauna Fl. Fenn. 5: 38. 1879.
Polyporus resinosus Fr., Syst. Mycol. 1:361. 1821.

Voucher specimen examined: San Gerardo de Dota, San Jose, L.D. Gomez 24240 (USJ 22872). (Altitudinal distribution: 2000 m).
Type of rot: White rot.
Substrata: On hardwood and softwood trees.
Distribution: North and Central America; Asia; Europe.

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MATING SYSTEMS IN MARASMIUS

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SUMMARY

Self-crosses of monokaryon isolates from single collections of thirteen species of *Marasmius* revealed the mating system for each taxon. These data, as well as previous mating reports on *Marasmius*, indicate a high consistency of mating system types at the sectional level. Sections *Alliacei*, *Androsaceus*, *Epiphylli*, and *Marasmius* are predominately tetrapolar (bifactorial), and sections *Globulares* and *Sicci* are bipolar (unifactorial).

About 90 taxa of Marasmius (Tricholomataceae, Agaricales) are known to occur in North America with 38 of these, representing eight sections, being reported from the southern Appalachian Mountains (Desjardin, 1989). While the majority of taxonomic works have treated alpha-level characters (macro- and micromorphology) (Desjardin, 1985, 1986, 1989; Desjardin and Petersen, 1989a, 1989b, 1989c; Gilliam, 1973, 1975, 1976), studies on cultural characteristics (Arnold, 1935; Desjardin, 1990) and phenoloxidase production (Marr, 1979; Desjardin, 1990) have also been produced. To date, few studies have extensively analyzed mating behavior in the genus. Relatively detailed reports on *Marasmius oreades* (Burnett and Evans, 1966; Mallet and Harrison, 1988), *Marasmius elongatipes* (= *M. pyrrhocephalus*; Arnold, 1935), and *Marasmius limosus* (Lamoure, 1957) have been made, while many studies listed in Lamoure's (1989) checklist of information on mating tests in the Agaricales have merely listed mating system type with no further information on collection deposition, unusual culture morphologies, or designation of tester strains.

Previous data suggested variability of mating systems within *Marasmius*, but with few species analyzed, resultant data, until now, have not been useful in systematic schemes. With the work by Desjardin (1989) providing a morphotaxonomic foundation for *Marasmius* in the southern Appalachian Mountains, it seemed opportune and interesting to obtain information on individual species' mating systems as well as to test generally accepted infrageneric outlines.

MATERIALS AND METHODS

COLLECTIONS - A major part of this research included extensive fieldwork throughout the southern Appalachian Mountains to collect living basidiomes from which monokaryon isolates were obtained. All collections were identified using keys by Desjardin (1989). Most collections were deposited in the University of Tennessee Fungus Herbarium (TENN) and tester strains of most collections (collection number in boldface below) have been deposited at ATCC.

CULTURE PREPARATION - Collection of spores and subsequent single-spore isolation was achieved by suspending the spore-bearing portion of a fresh basidiome from the inside cover of a tilted sterile Petri dish (to allow for greater spore dispersal) containing malt extract agar (MEA; 1.5% Difco malt extract, 2.0% Difco bacto-agar, 1 L distilled water). When a spore print became barely visible, the basidiome tissue was removed, and Petri dishes were inspected daily for spore germination.

Spore germination was detected using a dissecting microscope with substage illumination. After spores germinated, single germlings were harvested and transferred to individual Petri plates where they were allowed to grow to approximately 10-15 mm diam. These monokaryon cultures were subcultured to: 1) slanted MEA culture tubes and stored at 4°C for short-term storage; and 2) sterile vials (4 ml cap.) containing 10% glycerol and placed at -70°C for long-term storage.

DETERMINATION OF MATING SYSTEMS (SELF-CROSSES) - Monokaryons from a single collection were crossed in all possible combinations. Mycelial plugs were placed on MEA approximately 6-7 mm apart. Isolates crossed against themselves served as controls. Matings were allowed to grow for one to several weeks after a contact zone was established, to allow differentiation of contact zone morphologies. Matings were examined microscopically for the presence of clamp connections (presumptive evidence of a compatible mating) or their absence (incompatible mating). In most cases, clamp connections were readily observed directly at 250X on hyphae at the agar surface. In some cases, when clamps were small or appeared incomplete ("false clamps"), a small plug of contact zone hyphae and agar was removed, stained with phloxine, and viewed at high magnification (600X). Presence or absence of clamp connections was noted at the periphery of each mated colony to assess if possible nuclear migration occurred away from the contact zone. Tester strains (tester spores) of each mating type were chosen on the basis of mating type, relatively fast growth rate, and ability to form abundant clamp connections with compatible mating types. Under individual taxa summarized below, tester strains are denoted by an (*) next to the strain number.

RESULTS

Section *ALLIACEI*

MARASMIUS PYRRHOCEPHALUS Berk.

Mating system: Tetrapolar (bifactorial)

Isolate mating type assignment: ASM 6147 - A_1B_1: 11*; A_2B_2: 2, 6, 7, 13*; A_2B_1: 1, 5, 8, 9, 10*; A_1B_2: 3, 14*. **TENN 48759** - A_1B_1: 5*, 6; A_2B_2: 3*, 1; A_2B_1: 8, 4, 9*, 2; A_1B_2: 7 and 10*. **TENN 48760** - A_1B_1: 5, 3*; A_2B_2: 9*, 2; A_2B_1: 4, 10*; A_1B_2: 1, 6*, 7, 8. **TENN 48752** - A_1B_1: 1*, 3, 8; A_2B_2: 2*, 4, 5, 6; A_2B_1: 9*; A_1B_2: 7*, 10.

Comments: Nuclear migration was reciprocal. Colonies of compatible matings formed a very distinctive "heart shaped" area of white, appressed hyphae surrounded by cinnamon-brown aerial hyphae. "Flat" and "barrage" morphologies were distinctive.

Specimens utilized: Illinois, Jackson Co., Touch of Nature Reserve, 20.X.89, coll. RHP, det. RHP, field no. ASM 6147 (EIU no. 6147); North Carolina, Macon Co., Bull Pen Rd., vic. Slick Rock, 6.VI.89, coll. SAG, det. SAG, field no. 1992 (TENN no. 48759); North Carolina, Swain Co., GSMNP, Kephart Prong Trail, 8.VI.89, coll. SAG, det. SAG, field no. 1999 (TENN no. 48760); North Carolina, Macon Co., Highlands Biological Station, nature trail, 9.VI.89, coll. SAG, det. SAG, field no. 2711 (TENN no. 48752).

Section *ANDROSACEI*

MARASMIUS ANDROSACEUS (L.: Fr.) Fries

Mating system: Tetrapolar (bifactorial).

Isolate mating type assignment: **TENN no. 48757** - A_1B_1: 5, 6*, 10; A_2B_2: 4*, 11, 12; A_2B_1: 2*; A_1B_2: 1*, 7, 14.

Comments: Nuclear migration was reciprocal: no distinct contact zone morphology was noted.

Specimen utilized: North Carolina, Macon Co., Blue Valley, vic. Forest Rd. 79, 9.VI.89, coll. SAG, det. SAG, field no. 2705 (TENN no. 48757).

Section *EPIPHYLLI*

MARASMIUS FELIX Morgan

Mating type: Tetrapolar (bifactorial)

Isolate mating type assignment: **ASM 6148** - A_1B_1: 1, 4*, 11; A_2B_2: 7, 12*; A_2B_1: 2, 5*; A_1B_2: 3, 6*, 8, 9, 10.

Comments: Nuclear migration was reciprocal. "Flat" and "barrage" reactions were readily visible but were most apparent when viewing colony reverse.

Specimen utilized: Illinois, Jackson Co., Touch of Nature Reserve, 20.X.90, coll. ASM, field no. 6148, (EIU no. 6148).

Section *MARASMIUS*

MARASMIUS ROTULA (Scop.: Fr.) Fries

Mating system: Tetrapolar (bifactorial)

Isolate mating type assignment: **TENN 48352** - A_1B_1: 1*, 3, 6; A_2B_2: 2*, 5; A_2B_1: 7*, 8; A_1B_2: 4*, 9. TENN 48535 - A_1B_1: 1, 8*, 10; A_2B_2: 3*, 5; A_2B_1: 4, 7, and 9*; A_1B_2: not represented in the sample. **TENN 48461** - A_1B_1: 3*, 6; A_2B_2: 1, 5, 10*; A_2B_1: 2, 8, 9, 11; A_1B_2: 4, 12*; A_2B_2 + A_2B_1: 7 (see commentary). TENN 48753 - A_1B_1: 2*, 8, 10; A_2B_2: 1, 6*, 7; A_2B_1: 4, 11*; were , A_1B_2: 3*; A_1B_1 + A_2B_1: 5 (see commentary). **TENN 48751** - A_1B_1: 1, 7*; A_2B_2: 2, 4, 5*; A_2B_1: 3, 6, 8*; A_1B_2: 9, 10*.

Comments: Nuclear migration was reciprocal, with the exception of TENN 48535, in which clamp connections were restricted to the contact zone. Only three mating types were retrieved from TENN 48535. Incompatible matings clearly exhibited "flat" and "barrage" reactions. Fluffy to cottony peripheral hyphae usually were indicative of compatible matings. Isolate 48461:7 and 48753:5 were each compatible with two other mating types: it is believed that two hemicompatible spores were initially isolated.

Specimens utilized: Georgia, Rabun Co., vic. Double Bridges, 1.5 mi. from Rt. 28, 24.VIII.89, coll. RHP, det. RHP, field no. 2080 (TENN no. 48461); North Carolina, Macon Co., Bull Pen Rd., vic. Slick Rock, 21.VI.89, coll. RHP, det. RHP, field no. 1809 (TENN no. 48352); North Carolina, Macon Co., Otto, Coweeta Hydrologic Lab, Shope Creek Rd., 22.VI.89, coll. RHP, det. RHP, field no. 1816 (TENN no. 48535); North Carolina, Macon Co., Forest Service Rd. 1.5 miles from Shortoff Baptist Church, 1.VII.89, coll. SAG, det. SAG, field no. 2760 (TENN no. 48751); Tennessee, Blount Co., GSMNP, Chimney Tops trailhead, 27.VI.89, coll. SAG, det. SAG, field no. 2726 (TENN no. 48753).

Section *GLOBULARES*

MARASMIUS CYSTIDIOSUS (Smith & Hesler) Gilliam

Mating system: Bipolar (unifactorial)

Isolate mating type assignment: **TENN 48754** - A_1: 1, 2*, 4, 5, 8, 10; A_2: 3, 6, 7, 9*, 11, 12.

Comments: Nuclear migration was variable: no distinct contact zone morphology was noted.

Specimen utilized: North Carolina, Macon Co., Coweeta Hydrologic Lab, vic. 1.5 mi. from lab on Shope Creek Rd., 1.VII.90, coll. SAG, det. DED, field no. 2756 (TENN 48754).

MARASMIUS DECIPIENS Halling, Desjardin, and Tish

Mating system: Bipolar (unifactorial)

Isolate mating type assignment: **TENN 48755** - A_1: 1*, 2, 4, 5, 10, 12, and 13; A_2: 7*, 9, 11. **TENN 48756** - A_1: 1, 5, 8*, 11; A_2: 2, 6, 9, 10*.

Comments: Clamp connections were mostly restricted to the contact zone. Many matings showed sparse, scattered clamps in the contact zone. Crosses performed on 1.5% MEA produced no discernably patterned grids but crossess on 0.5% MEA showed clear bipolar patterns.

Specimens utilized: Tennessee, Blount Co., GSMNP, vic. Chimney Tops trailhead, 27.VI.89, coll. SAG, det. DED, field no. 2722 (TENN no. 48755); North Carolina, Haywood Co., Cataloochee cove, 30.VI.89, coll. SAG, det. DED, field no. 2731 (TENN no. 48756).

MARASMIUS NIGRODISCUS (Pk.) Halling

Mating system: Bipolar (unifactorial)

Isolate mating type assignments: **TENN 48829** - A_1: 1, 4*, 6, 11; A_2: 2*, 3, 5, 7, 8, 9, 10, 12.

Comments: Clamp connections were restricted to the zone of contact. No distinct contact zone morphology was noted. Crosses performed on 1.5% MEA produced no discernably patterned grids, but crosses on 0.5% MEA exhibited clear bipolar patterns.

Specimen utilized: Tennessee, Knox Co., Knoxville, University of Tennessee campus, 21.VI.89., coll. DED, det. DED, field no. 4913 (TENN no. 48829).

MARASMIUS OREADES (Bolt.: Fr.) Fries

Mating system: Bipolar (unifactorial)

Isolate mating type assignment: **TENN 48827** - A_1: 3, 6, 7*, 15, 16, 17; A_2: 2, 8, 11*, 12, 13, 14.

Comments: Nuclear migration was reciprocal: no distinct contact zone morphology was noted.

Specimen utilized: New York, Cortland Co., Rt. 281, vic. St. Mary's Cemetary, 18.X.89, coll. TJB, det. TJB, field no. TJB 6314 (TENN no. 48827).

MARASMIUS STRICTIPES (Pk.) Singer

Mating system: Heterothallic

Isolate mating type assignment: Inconclusive at this time

Comments: No discernable mating patterns were observed. Matings were read weekly for four weeks; mating data remained consistent at all reading times.

Specimen utilized: Illinois, Jackson Co., Touch of Nature Reserve, 21.X.89, coll. RHP, field no. 2427 (TENN no. 48761).

Section *SICCI* Series *HAEMATOCEPHALI*

MARASMIUS FLORIDANUS Murrill

Mating system: Bipolar (unifactorial)

Isolate mating type assignment: **ASM 5707** - A_1: 1, 2*, 3, 4, 5, 6, 8, 9; A_2: 7, 10*, 11, 12.

Comments: Nuclear migration was variable, some crosses formed clamp connections which seemed restricted to the contact zone while others exhibited reciprocal migration.

Specimen utilized: Illinois, Douglas Co., Walnut Pt. State Park, 13.VII.89, coll. ASM, det. ASM, field no. ASM 5707 (EIU no. 5707).

MARASMIUS PULCHERRIPES Peck

Mating system: Bipolar (unifactorial)

Isolate mating type assignment: **TENN 48758** - A_1: 1, 2, 3, 4, 5*, 8; A_2: 6, 9*. **TENN 48750** - A_1: 2*, 3, 4, 6, 7; A_2: 1, 5*, 8, 9, 10, 11.

Comments: No distinct contact zone morphology was noted. Analysis of clamp connections required high magnification (600X).

Specimens utilized: Georgia, Rabun Co., vic. Warwoman Dell Picnic Area, 18.VII.89, coll. SAG, det. SAG, field no. 2779 (TENN no. 48750); Tennessee, Blount Co., GSMNP, 1 mi. past Park Visitors' center, 1.VIII.89, coll. SAG, det. SAG, field no. 2127 (TENN no. 48758).

MARASMIUS SICCUS (Schw.) Fries

Mating system: Bipolar (unifactorial)

Isolate mating type assignment: **TENN 48828** - A_1: 1, 2*, 3, 7, 8, 13, 15; A_2: 4*, 5, 6, 9, 10, 11, 12, 14. **DED 4956** - A_1: 1, 4, 5*, 7, 9, 10; A_2: 2, 3*, 6, 8.

Comments: No distinct contact zone morphology was noted. Observation of clamp connections required high magnification (600X).

Specimens utilized: North Carolina, Haywood Co., Harmon Den, 18.IX.88, coll. DED, det. DED, field no. DED 4714 (TENN no. 48828); Ohio, Loraine Co., 8 mi. west of Oberlin, vic. Girl Scout Camp, 11.IX.89, coll. DED, det. DED, field no. DED 4956 (SFSU).

Series *LEONINI*

MARASMIUS FULVOFERRUGINEUS Gilliam

Mating system: Bipolar (unifactorial)

Isolate mating type assignment: **TENN 48464** - A_1: 2, 3, 5*, 7, 12, 18; A_2: 6, 9*, 10, 19.

Comments: Nuclear migration was reciprocal.

Specimen utilized: Georgia, Rabun Co., Warwoman Dell Picnic Area, 28.VIII.89, coll. RHP, det. RHP, field no. 2099 (TENN no. 48464).

DISCUSSION

The thirteen species studied represented six sections of *Marasmius*. Eight species were bipolar, four tetrapolar, and one inconclusive (Table I). When mating system data from this study as well as those from previous reports are compared to the infrageneric system in Desjardin's (1989) regional flora, mating system types appear remarkably consistent at the sectional level. Understanding that the infrasectional sampling sizes were extremely low, the conclusions below nevertheless seem warranted.

Section *Alliacei* was represented in this study by *M. pyrrhocephalus* (4 collections), which was found to be tetrapolar. Other taxa in this section also have been shown to be tetrapolar; Kühner (1945), Piroard (1956), Terra (1953), and Yen (1950c,d) for *M. scorodonius* (Fr.: Fr.) Fr.; Piroard (1956), Terra (1959), and Yen (1950 a,b) for *M. alliaceus* (Jacq.: Fr.) Fr.; and Lamoure (1989) for *M. epidryas* Kühner. Bastouill (1977) and Viale (1961) found *M. prasiomus* (Fr.: Fr.) Fr. to be heterothallic but did not indicate a specific mating system. The section, thus far, seems consistently tetrapolar.

In section *Androsacei*, only *M. androsaceus* was obtained in single-spore culture. It was found to be tetrapolar, supporting previous reports by Piroard (1956), Terra (1953), and Yen (1950a,b,d). Because it is

TABLE I

MATING SYSTEMS OF *MARASMIUS* TAXA[1]

SECTION	MATING SYSTEM
SECTION *ALLIACEI*	
M. pyrrhocephalus (nos. 2419, 1992, 1999, 2711)	tetrapolar
SECTION *ANDROSACEUS*	
M. androsaceus (no. 2705)	tetrapolar
SECTION *EPIPHYLLI*	
M. felix (s. n.)	tetrapolar
SECTION *MARASMIUS*	
M. rotula (nos. 1809, 1816, 2080, 2726, 2760)	tetrapolar
SECTION *GLOBULARES*	
M. cystidiosus (no. 2756)	bipolar
M. decipiens (nos. 2722, 2731)	bipolar
M. nigrodiscus (no. 4913)	bipolar
M. oreades (no. 6314)	bipolar
M. strictipes (no. 2427	inconclusive
SECTION *SICCI*	
M. floridanus (no. 5707)	bipolar
M. siccus (nos. 4714, 4956)	bipolar
M. pulcherripes (nos. 2127, 2779)	bipolar
M. fulvoferrugineus (no. 2099)	bipolar

[1] collection field numbers in parenthesis

the only species in the section whose mating system is known, mating system analysis of other species in this section is necessary before conclusions can be drawn on sectional mating system consistency.

In our cultured collections, section *Epiphylli* was represented by *M. felix*, which was tetrapolar. Terra (1953) and Yen (1950a,b,d) found the same system in *M. epiphyllus* (Pers.: Fr.) Fr. *Marasmius tremulae* Vel., conversely, has been reported as haploid parthenogenetic by Kühner (1947) and Lamoure (1958).

From limited data, section *Marasmius* seems to be predominately tetrapolar. *Marasmius rotula* (5 collections) was found to be tetrapolar, agreeing with Terra (1953) and Yen (1950b,d). Moreover, Lamoure (1960, 1989) reported the European taxa *M. bulliardii* Quél. and *M. limosus* Boud. & Quél. as tetrapolar.

Mating systems of five species in sect. *Globulares* were analyzed in this study. *Marasmius decipiens*, *M. nigrodiscus*, *M. cystidiosus*, and *M. oreades* were all found to be governed by bipolar mating systems, while *M. strictipes* remains unresolved at this time. Conversely, Armand (1962), Oddoux (1957), and Terra (1959) sited a tetrapolar mating system for *M. collinus* (Scop.: Fr.) Sing., inconsistent with our mating system data on this section. Data on a bipolar mating system for *M. oreades* are in agreement with Mallet and Harrison (1988) and Burnett and Evans (1966).

Taxa of section *Globulares* seem to differ physiologically from those in other studied sections of *Marasmius*. When self-crosses of some taxa of this section (*Marasmius decipiens*, *M. nigrodiscus*, and *M. strictipes*) were performed on 1.5% malt extract agar, compatible crosses were unpatterned and less common than in crosses on 0.5% malt extract agar. It appeared that some sexually compatible monokaryons were reluctant to dikaryotize on the higher nutrient medium. Exceptions to these observations were *M. oreades* and *M. cystidiosus*, which dikaryotized in conclusive patterns on both media, and *M. strictipes* which produced no patterned mating reactions on both media.

In section *Sicci*, mating systems of taxa from two series, *Haematocephali* and *Leonini*, were elucidated. In series *Haematocephali*, *M. floridanus*, *M. siccus*, and *M. pulcherripes* were all found to be bipolar. *Marasmius fulvoferrugineus*, of series *Leonini*, also was found to be bipolar. Armand (1962) and Vandendries (1936) found *M. cohaerens* (Pers.: Fr.) Fr., a member of section *Sicci* series *Spinulosi*, also to be bipolar, indicating consistent bipolar mating behavior throughout section *Sicci*.

Marasmius sullivantii (sect. *Sicci*, ser. *Haematocephali*) was collected but subsequent "monospore" isolates were all clamped. Suspecting that basidiospores could be binucleate and the species amphithallic, spores of dried specimens were examined using epifluorescence microscopy and the nuclear flourescent stain DAPI (4'-6-diamidino-2-phenylindole). Spores appeared to contain one nucleus, but many spores seemed closely associated with or attached to one another. This spore adhesion may have caused multiple spores to be harvested during single-spore isolation attempts.

While these data indicate heterogeneous mating systems in *Marasmius*, *Mycena* (Kühner, 1938) has also been shown to posses several mating system types. Other limited data on white-spored agarics indicate homogeneous mating system types at the generic level, with *Collybia* (Arnold, 1935; Chu, 1950; Vilgalys and Miller, 1983, 1987), and *Marasmiellus* (Gordon, unpub. data) appearing consistently tetrapolar. Limited data on *Xerula* (Redhead, *et al.*, 1987, Petersen, unpub. data) and *Hohenbuehelia* (Thorn and Barron, 1986; Petersen, unpub. data) indicate consistent bipolar mating sytems.

Our data for *Marasmius* indicate a probability that genes controlling mating system type act separately from those governing morphological characters, especially those defining generic parameters. Implicit in this hypothesis is the following dichotomy: either 1) divergence of compatibility systems (bipolar > tetrapolar; tetrapolar > bipolar) occurred more than once after stabilization of morphological infrageneric diagnostic characters; or 2) within a coherent group governed by a single mating system (i. e. bipolar; tetrapolar), morphologically divergent groups evolved. Sections *Alliacei*, *Epiphylli*, and *Globulares* exhibit a palisade pileipellis of non-setulose clavate cells (Desjardin, 1989; Singer, 1986). Our data indicate that two of these sections, *Alliacei* and

Epiphylli are tetrapolar, while section *Globulares* appears bipolar. Likewise, sections *Marasmius* and *Sicci* are characterized by pileipelli containing setulose elements (broom cells) (Desjardin, 1989; Singer, 1986). Of these, section *Marasmius* appears tetrapolar while section *Sicci* is bipolar. To cluster sexually like sections would require extraction of two morphologically dissimilar sections (*Globulares*, *Sicci*) from groups to which they are typically thought to belong (Desjardin, 1989; Singer, 1986). In summary, either the morphogenus is "natural," in which case mating systems have evolved more than once within the morphogenus, or if mating systems are used to diagnose generic units (= biogenus), then a multiplicity of morphogeneric units must be defined.

Because mating systems of only a few congeneric taxa have been analyzed, data from which to infer evolutionary relationships and positions relative to mating system analysis are still in an early state.

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SPECIES CONCEPTION AND SECTIONS DELIMITATION OF GENUS DISCOSIA

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ABSTRACT. Six new sections of genus *Discosia* Lib. (Sect. I. *Discosia*, Sect. II. *Laurina* Vanev, sect. nov., Sect. III. *Clypeata* Vanev, sect. nov., Sect. IV. *Libertia* Vanev, sect. nov., Sect. V. *Strobilina* Vanev, sect. nov., Sect. VI. *Poikilomera* Vanev, sect. nov.) are delimited on the basis of some morphologic characters: number of septa, relative length of the 2 middle conidial cells and different points of origin of the conidial appendages. The new sections are described and illustrated.

Genus *Discosia* Lib. was described by Libert in 1837 with 2 original species: *D. faginea* Lib. and *D. strobilina* Lib. From the diagnosis it is evident that the author wrongly refers the new genus to class *Ascomycetes*: "Char. gen. Perithecium innatum scutiforme ostiolo perforatum obtegens ascida fusiformia utrinque in productionem filiformem protensa, sporidiis globosis".

Later De Notaris (1849) described 4 new species of genus *Discosia*: *D. vagans* De Not., *D. quercicola* De Not., *D. smilacina* De Not. and *D. clypeata* De Not.

Fries (1849) suggests the combination *D. artocreas* (Tode)Fr., transfering the species *Sphaeria artocreas* Tode, described by Tode (1791), to genus *Discosia*. At present, the same species is fixed as a lectotype of the genus (Vanev, in press)

On the basis of detailed investigations on the morphological peculiarities of some species from that genus, Fresenius (1852) finds out that the sporidia mentioned in the original description of the genus by Libert (l. c.) are oil drops, while the conidia proper have been wrongly registered as ascuses. Genus Discosia, therefore, should be excluded from class Ascomycetes and refered to the imperfect fungi.

Later, a series of investigators define and describe a huge number of new taxa, as a result of which more than 80 species, varieties and forms are known to be within the limits of that genus nowadays (Berkeley 1874, Cavara 1889, Edwards 1972, Gerard 1873, Heald 1909, Hollós 1907, Kalani 1966, Lacy 1958, Morgan-Jones 1964, Peck 1893, Petrak 1951, Saccardo 1884, 1892, 1895, 1906, Tehon 1933, Tilak & Viswanathan 1959, Vanev 1982, etc.).

The morphological similarity among the representatives of that genus, together with the lack of accurate taxonomic criteria for their differentiation are the basic reasons for the presence of a great number of species whose morphological differentiation is either difficult, or impossible.

Following the established traditions in the classification of the imperfect fungi, the investigators have described a number of new species above all on a physiological principle: on the basis of the plants, upon which they have been originally registered, with the taxa, newly differentiated with respect to nomenclature, being linked most often either with the name of the genus, or with the species epithet of the host-plant (D. pini Heald D. rhododendri Speschnev, D. platani Otth, etc.).

Genus Discosia unites both saprophytes and typical parasites. In our investigations it was established, that many of the taxa described are not firmly attached to a definit substrate, therefore it is both groundless and wrong to isolate separate, independent units out them.

Differentiating the infrageneric taxa, the investigators have been working so far on the basis of some morphological features having unequal taxonomic value, for example: while the morphological features of the conidia are caracterized with a relative stability, their application in the differentiation of the individual taxa being perfectly reasonable, such features as size, shape and location of the pycnidia (frequently used so far) are rather variable, possessing an insignificant value in the genus classification.

One characteristic peculiarity in the systematics of genus Discosia is the presens of the collective species D. artocreas (Tode) Fr. Quite a number of investigators, not being able to refer this or that species to the ones already described in the genus, have made "use" of the collective species. In the mycological herbaria all over the world a huge number of specimens are deposited, defined as D. artocreas.

Revising more than 2500 specimens from genus Discosia, deposited in 36 well-known mycological herbaria all over the world, we established that almost 1/3 of them are kept under the name of D. artocreas.

The taxonomic scheme of the genus existing up to now, based predominantly on a physiological principle (attachment to a definite plant substrate), has obviously not satisfied some of the mycotaxonomists, who deposited the materials they had collected, as unidentified (sub Discosia sp.), or referred them to the collective species D. artocreas.

Some of the investigators have tried to break the tradition looking for other features, mostly morphological ones, to differentiate the individual species. Fresenius (l.c.) took notice in his day, both of the differences in the location of the septa in the conidia and of the formation of the conidial appendages in various species of genus Discosia. Evolving his theory, a century later, Morgan-Jones (l.c.) tried to differentiate 5 species (D. strobilina Lib., D. deflectens Sacc., D. inaequalis (Tehon & Stout) Morgan-Jones, D. violae (Tehon & Daniels) Morgan-Jones, D. pini Heald) from D. artocreas on the basis of the conidial appendages' location.

The Indian investigators Subramanian & Chandra-Reddy (1974) have studied some specimens from that genus finding out a high degree of stability in such morphological features as the location of conidial septa and the exact place of formation of the conidial appendages. On those grounds, the above-mentioned authors have differentiated 7 species, dividing them into 4 groups. One important flaw in Subramanian & Chandra-Reddy's work is the extremely limited number of type specimens (just 5) they studied, which prevented them from taking any important taxonomic decisions.

Morgan-Jones (l.c.) and Sutton (1980) have suggested for Discosia's genus characterization and for the differentiation of the species to have in mind, first of all, the conidiogenesis and the morphology of the conidiogenous apparatus.

Notwithstanding some attempts at a new approach the species' differentiation within the limits of genus Discosia, no modern classification scheme of that genus has been elaborated so far, and, as Sutton (l.c.) says the question about the infrageneric structure of genus Discosia is still open.

A prime task, facing us when revising that genus taxonomically was to determine the species conception and to select the most appropriate taxonomic criteria.

As the base of the classification scheme we elaborated , we accepted the morphological principle to be the basic one, differentiating the infrageneric taxa predominantly on the basis both of the conidial morphology and the conidiogenous apparatus structure. Studying a huge number of specimens, originating from various parts of the world, we found out that the most constant features possessing a high taxonomic value are the following: the size, the shape and the colour of the conidia; the location of the conidial septa and appendages, together with the size and shape of the conidiogenous cells. Due to their variability, the morphological peculiarities of the pycnidia are only of a tentative character.

The location of the conidial septa, determining the size of the conidial cells, is quite a characteristic morphological feature with a considerable taxonomic value. The conidia of all specimens we studied have 3 transverse septa each (only in D. poikilomera and D. baarnensis their number is 4), dividing them into 4 cells. In the process of the study, 3 types of location of the middle septum in the conidium werw found out: 1. Located at an equal distance from the 2 end septa, that leading to a relatively equal length of the 2 middle cells ($C_2=C_3$). 2. Located nearer to the apex, when the middle cell adjacent to the base of the conidium is longer than the middle cell adjacent to the apex ($C_2 > C_3$). 3. Located nearer to the base, when the middle cell adjacent to the apex of the conidium is longer than the other middle cell adjacent to the base ($C_2 < C_3$) .

A definite type of location of the middle conidial septum ischaracteristic for each of the studied specimens, that allowing for their allocation into 3 groups on the base of that feature. Greatest in number is the group of specimens with conidia of the second type, specimens with conidia of the third type being observed quite rarely.

Two types of formation of the conidial appendages were observed: 1. On the very margin of the conidium just next to the apex and to the base. 2. Considerably nearer to the middle of the conidium, next to the 2 end septa.

It is important from a taxonomic point of view, that one of the two types of formation of the conidial appendages is characteristic for each specimen, that allowing for allocation of the studied specimens into 2 groups on the base of that feature.

A characteristic peculiarity of the conidia of all specimens, belonging to genus Discosia, is their having a rounded apex and a truncate base, that eliminating all difficulties in defining the basal and the apical cells in the studied conidia.

Accepting Subramanian and Chandra-Reddy's idea how to group the taxa within the limits of the genus Discosia on the base of the location of the conidial septa and appendages, we delimited the following 6 sections:

Section I. DISCOSIA. Conidia quadricellularia; semper longior cellula media, vicina basis, quam cellula media, vicina apicis; appendices proxime apicem basimque conidii formantur.

Typus: Discosia artocreas (Tode) Fr.

The conidia 4-celled; the middle cell, adjacent to the base, always longer than the middle cell, adjacent to the apex; the appendages arising just next to the apex and to the base of the conidium (Fig. 1).

Section II. LAURINA Vanev, sect. nov. Conidia quadricellularia; duae cellulae mediae fere aequilongae; appendices proxime apicem basimque conidii formantur.

Typus: Discosia laurina Cald.

The conidia 4-celled; the two middle cells almost equal in length; the appendages arising just next to the apex and to the base of the conidium (Fig. 2).

Section III. CLYPEATA Vanev, sect. nov. Conidia quadricellularia; semper brevior cellula media, vicina basis, quam cellula media, vicina apicis; appendices proxime apicem basimque conidii formantur.

Typus: Discosia clypeata De Not.

The conidia 4-celled; the middle cell, adjacent to the base always shorter than the middle cell, adjacent to the apex; the appendages arising just next to the apex and to the base of the conidium (Fig. 3).

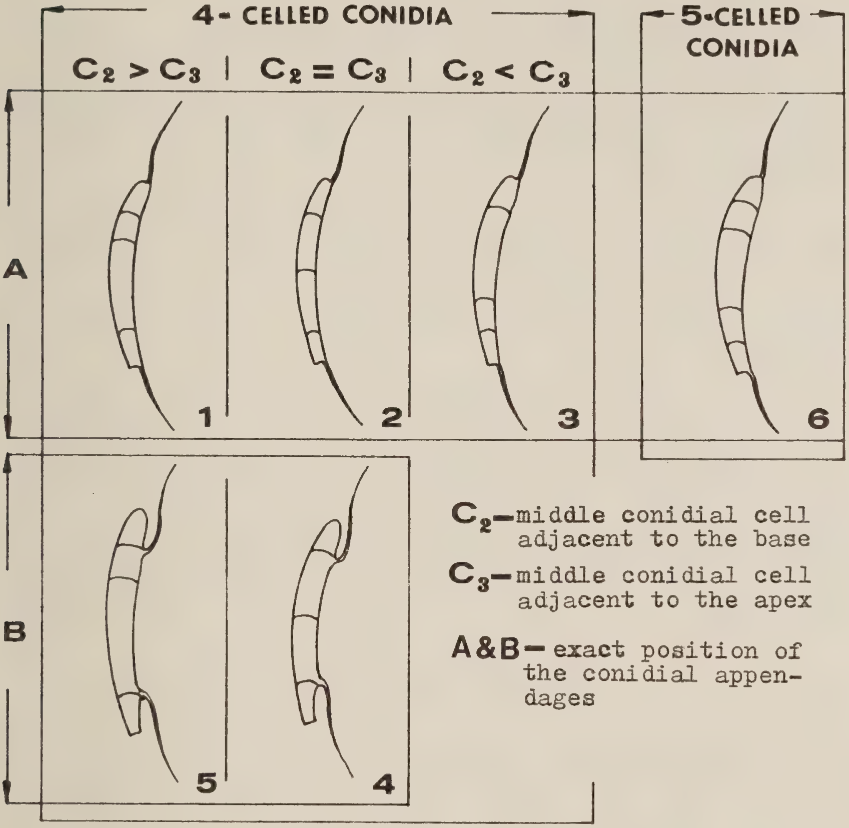
Section IV. LIBERTIA Vanev, sect. nov. Conidia quadricellularia; duae cellulae mediae fere aequilongae; appendices proxime duo septa extrema formantur.

Typus: Discosia pyri Koschkelova

The conidia 4-celled; the two middle cells almost equal in length; the appendages arising next to the two end septa (Fig. 4).

Section V. STROBILINA Vanev, Sect. nov. Conidia quadricellularia; semper longior cellula media, vicina basis, quam cellula media, vicina apicis; appendices proxime duo septa extrema formantur.

Typus: *Discosia strobilina* Lib.


4- CELLED CONIDIA
5-CELLED CONIDIA
$C_2 > C_3$
$C_2 = C_3$
$C_2 < C_3$
A
B
1
2
3
6
5
4
C_2—middle conidial cell adjacent to the base
C_3—middle conidial cell adjacent to the apex
A&B—exact position of the conidial appendages

Figs. 1-6. Sections of genus *Discosia*. 1. Section *Discosia*. 2. Section *Laurina*. 3. Section *Clypeata*. 4. Section *Libertia*. 5. Section *Strobilina*. 6. Section *Poikilomera*.

The conidia 4-celled; the middle cell, adjacent to the base, always longer than the middle cell, adjacent to the apex; the appendages arising next to the two end septa (Fig. 5).

Section VI. POIKILOMERA Vanev, sect. nov. Conidia quinquecellularia; cellula media semper longissima, quattuor cellulae reliquae fere aequilongae; appendices proxime apicem basimque conidii formantur.

Typus: Discosia poikilomera Fairman

The conidia 5-celled; the middle cell always the longest, the other 4 ones almost equal in length; the appendages arising just next to the apex and to the base of the conidium (Fig. 6).

The differentiation of the species within the limits of each section is made on the base of the differences in the morphology of the conidia and of the conidiogenous cells as well as the parasitism or the saprophytism of the species.

The comparative morphological studies we made on over 2500 herbarium specimens (among them more than 90% of the type and original materials from the taxa known up to now) we found out 31 good species, that must be referred to genus Discosia. Twenty-eight taxa were excluded from the genus, 9 others having an unidentified taxonomical status.

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STUDIES IN THE GENUS CLADOSPORIUM SENSU LATO. IV. CONCERNING CLADOSPORIUM OXYSPORUM, A PLURIVOROUS, PREDOMINANTLY SAPROPHYTIC SPECIES IN WARM CLIMATES

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ABSTRACT

Cladosporium oxysporum Berk. & Curt., a species occurring commonly in the tropics and subtropics on a wide range of herbaceous and woody substrates, is redescribed and illustrated from a number of collections, including its type. It has been isolated in culture and its characteristics *in vitro* are also reported upon.

INTRODUCTION

Cladosporium oxysporum Berk. & Curt. was first collected on dead leaves of a species of *Passiflora* L. in Cuba. The original description (Berkeley, 1868) reads as follows: "*C. oxysporum* B. & C. Soris pallidis olivaceis; floccis pallidis hic illic ramosis laevibus; sporis ex obovatis submetulaeformibus. On dead leaves of *Passiflora* L. Spores .0006-.0003 inch long."

The same brief description was repeated verbatim by Saccardo (1886), but conidium length was given as "7-14 µm longis". Although, according to Ellis (1971), the fungus is common and widespread in tropical regions on dead leaves and stems of herbaceous and woody plants, it remained inadequately characterized and described for over a century and there appear to have been few records of its occurrence. No mention was made of it by de Vries (1952) in his studies on the genus *Cladosporium* Link. Surprisingly, no records of it were reported by some hyphomycetologists collecting extensively in tropical or subtropical regions such as, for example, Subramanian (1971) and Matsushima (1971; 1975) [and the latter author's Matsushima Mycological Memoirs Nos. 1 through 6 (1980-1989)]. Both these authors encountered and described a number of *Cladosporium* species, but not *C. oxysporum*.

The fungus is generally regarded to be a saprophyte, although Fisher (1967) implicated it as the causal organism of a severe leaf-spot disease of young citrus trees at a nursery in Polk County, Florida. Five species of citrus showed symptoms: *Citrus aurantifolia* (L.) Swingle, *Citrus limon* (L.) N.L. Burm., *Citrus paradisi* Macfady, *Citrus reticulata* Blanco and *Citrus sinensis* (L.) Osbeck. Leaf spots were superficially similar to initial lesions on *Citrus*

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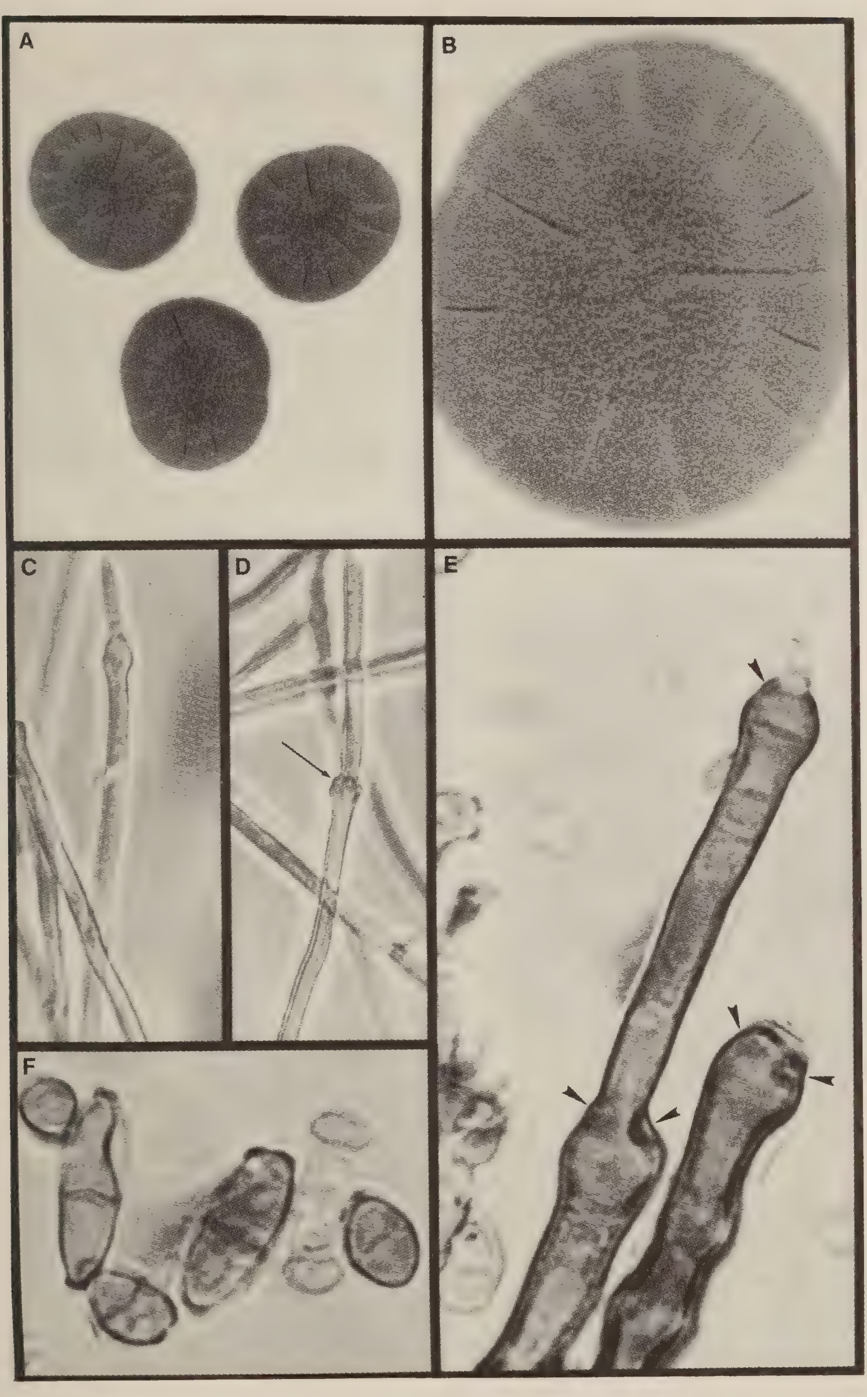
caused by *Cercospora citri-grisea* F.E. Fisher and *C. gigantea* F.E. Fisher, (Fisher, 1961). The latter species is the causal organism of tar spot. Conidiophores of *C. oxysporum* [identified at the then Commonwealth Mycological Institute by C. Booth] were found on necrotic tissue in tan to brown depressed areas bordered by a dark brown, slightly raised margin on the leaves. The fungus was not isolated *in vitro* and, since no inoculation experiments fulfilling Koch's postulates were conducted, it seems possible that *C. oxysporum* might have been a secondary invader on preexisting necrotic leaf spots. Judging by Fisher's account, however, this seems somewhat unlikely. No further report of this disease, to our knowledge, has been published; therefore, the role of *C. oxysporum* as a leaf-spot inducing fungus needs to be confirmed.

In the United States, during the past two decades, *C. oxysporum* has been reported from a number of different and diverse hosts, including *Alnus*, *Bambusa*, *Citrus*, *Helianthus* and *Pseudotsuga* (Farr *et al.* 1989). Sherwood and Carroll (1974) found the fungus growing on twigs of old-growth Douglas fir [*Pseudotsuga menziessii* (Mirb.) Franco] in Oregon during a study of fungal succession on needles and young twigs. Morgan-Jones (1977) reported its occurrence on leaves of *Bambusa* sp. in Alabama and Rossman and Lu (1980) reported isolating it from leaf surfaces of both red alder [*Alnus rubra* Bong.] and Douglas fir seedlings in western Oregon. Its occurrence in Oregon suggests that it might be more cosmopolitan in distribution than previously thought. Roberts *et al.* (1986), in a study of fungi occurring in achenes of sunflower [*Helianthus annuus* L.] from several production areas in Georgia, isolated *C. oxysporum* on one occasion from preharvest seed in a total sample of over twenty eight thousand seeds plated onto agar media. Other species of *Cladosporium* Link, particularly *C. cladosporioides* (Fres.) de Vries and *C. cucumerinum* Ellis & Arth., occurred at much higher frequencies. Although considered to be common, *C. oxysporum* may not be as ubiquitous as some other species of the genus *Cladosporium*.

Ellis (1971) provided a brief description of *C. oxysporum*, thereby making its characteristics, including its morphology, *in vivo* better known. No account of the fungus in culture was given except for mention of the fact that colonies on agar are cottony or loosely felted. It is interesting to note that all except one of the above cited records were published subsequent to Ellis' publication. It is assumed that the identifications made were correct. In our continuing efforts to provide modern, comprehensive accounts of *Cladosporium* species (Morgan-Jones and McKemy, 1990; McKemy and Morgan-Jones, 1990; 1991), including characteristics *in vitro*, a new description together with illustrations of *C. oxysporum* is published herein. These are based on several specimens from various localities, including its type from Cuba, and an isolate obtained from a partly decayed leaf of *Lespedeza bicolor* Turcz., collected in a greenhouse at Auburn University. Examination of the type has confirmed the interpretation of the species by Ellis (1971) to be accurate.

PLATE 1. *Cladosporium oxysporum*. A, 7-day-old colonies on PDA at 25C; B, enlargement of one of the same, illustrating surface texture; C, conidiophore from culture on PDA showing characteristic terminal extension above a fertile, swollen, conidiogenous portion; D, conidiophore from culture on PDA showing very slightly papillate conidiogenous loci (one indicated by arrow); E, macronematous conidiophores from nature showing darkened conidial scars (indicated by arrowheads); F, conidia from nature.


A
B
C
D
E
F

TAXONOMIC PART

Cladosporium oxysporum Berk. & Curt., *J. Linn. Soc.*, 10(46): 362, 1868 (Plate 1, Figures 1 and 2).

Colonies in nature effuse, greyish brown, somewhat thin, hairy. Mycelium mostly immersed in the host tissue, composed of branched, septate, smooth, subhyaline to pale-brown hyphae, 3-4 µm wide. In older colonies, hyphal cells often becoming variously inflated, somewhat more pigmented, thick-walled, and occasionally assuming chlamydospore-like morphology, up to 12 µm in diameter. Colonies on potato dextrose agar (PDA) [Difco] grown at 25C attaining a diameter of 25 mm and 55 mm after 7 and 14 days, respectively. After 7 days (Plate 1, A & B), colonies densely lanose toward the center, becoming progressively velvety toward the periphery, distinctly sulcate, with radial furrows extending outward various distances from near or at the edge of the central lanose portion, coloration varying from Dark Green [30F5] centrally to Greenish Grey [30E2] peripherally (Kornerup and Wanscher, 1978), margin even and whitish. After 8 or 9 days, same colonies rapidly becoming Olive to Olive Green [1F6 to 2F6] as a result of abundant conidiation. Colony reverse Bronze Green [30F3] with radial furrows of different length and depth, margin white. Colonies on PDA at 20C and 30C attaining a diameter of 22 and 10 mm after 7 days, respectively; appearance and coloration similar to those at 25C, but somewhat denser at 30. Conidiophores in nature macronematous, mononematous, erect, straight, rigid to slightly flexuous, smooth, cylindrical, distinctly nodose, with terminal and intercalary swellings, thick-walled, cicatrized, scars prominent (Plate 1, E; Figure 1), septate, rarely branched, mid to pale brown, bulbous at the base, up to 400 µm long X 4-5 µm wide, up to 10 µm wide at the base, usually 6-8 µm; nodes 6-9 µm in diameter. In the terminal, fertile portions, conidiophore septae mostly proximal to, above or below, the nodes. In culture, conidiophores macronematous or semi-macronematous, mononematous, mostly flexuous, more slender than in nature and generally thinner-walled, pale olive green to light brown, up to 650 µm long X 4-5 µm wide, nodes 5-6 µm wide, with conidiogenous loci sometimes slightly papillate (Plate 1, D). Conidiogenous cells holoblastic, polyblastic, integrated, terminal but becoming intercalary, sympodial. Conidiation limited to successively produced swollen portions. Ramo-conidia in nature cylindrical to clavate or ampulliform, sometimes very slightly curved, smooth, 0-3 septate, cicatrized, mid to pale brown, up to 25 (6-15) µm long, 5-6 µm wide, occasionally somewhat papillate at one or more conidiogenous loci; in culture, paler in color, 0-1 septate, up to 30 µm long, mostly 8-12 µm, 4-5 µm wide. Intercalary conidia in nature ellipsoidal to limoniform, oblong or fusiform, pale olive brown, smooth, 0-2 septate, 3-8 µm wide, up to 20 µm long; in culture 0-1 septate, 3-5 µm wide, up to 15 µm long. Terminal conidia globose to mostly subglobose, 3-5 µm.

Plurivorous; widespread in tropical and subtropical regions.

Collections examined: on dead leaves of *Passiflora*, Cuba, C. Wright (489), K, holotype; on pods of *Adenanthera pavomina* L., Boyama, Cuba, November 13, 1967, R. Urtiago, IMI 130161, AUA; isolated ex *Arachis hypogeae* L., Lundhiana, Punjab, India, September 7, 1968, J.S. Chohan, IMI 134246, AUA; on *Triticum aestivum* L. [as *T. vulgare* Vill.], from El Salvador, intercepted at San Francisco, California, U.S.A., January 12, 1973, BPI 427305, AUA; on *Ullucus tuberosus* Caldas, from Ecuador, intercepted at Miami, Florida, U.S.A., December 14, 1975, BPI 427306, AUA; on leaves of *Bambusa* sp., Chewacla State

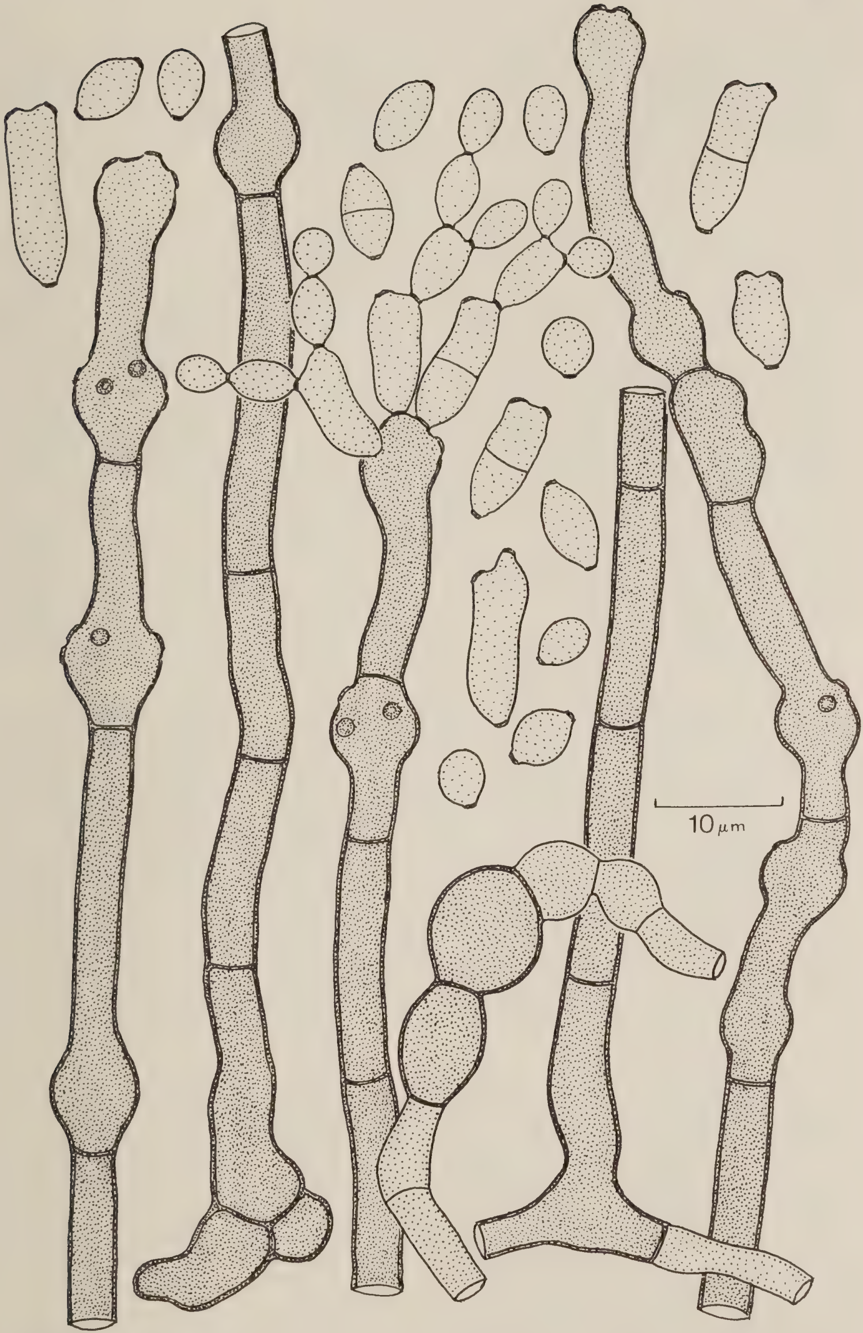


FIGURE 1. *Cladosporium oxysporum*. Conidiophores, conidia and swollen chlamydospore-like cells from nature.

Park, Lee Co., Alabama, U.S.A., April 1976, G.W. Karr, Jr., AUA; on dead leaves of *Quercus* sp., Pienaar's River Bank, Pretoria, South Africa, April 3, 1979, R.C. Sinclair, AUA; on a partly decayed leaf of *Lespedeza bicolor*, Auburn University, Lee Co., Alabama, U.S.A., March 1990, J.M. McKemy, AUA [Isolate derived from this collection has been deposited at ATCC.]

DISCUSSION

The intermittently determinate conidiophores of *C. oxysporum* are, together with those of *C. colocasiae* Sawada, unique in the genus *Cladosporium*. These two species are, in fact, closely similar, differing mainly in the latter having wider, thicker-walled, darker, more septate conidia that are often broader toward each end than in the middle. Conidia of *C. colocasiae* also bear distinctly protuberant scars and its conidiophores are, generally, somewhat more robust than those of *C. oxysporum*. In addition, it is host-specific to *Colocasia* spp., causing round or irregular, brown, necrotic leaf-spots. The morphological differences between *C. colocasiae* and *C. oxysporum* are akin, and similar in degree, to those distinguishing *C. herbarum* (Pers.) Link, the lectotype species of the genus, and *C. macrocarpum* Preuss, two entities considered to be conspecific by some (e.g. Barr, 1958), but kept separate by others (e.g. de Vries, 1952; Ellis, 1971). *Cladosporium herbarum* is the anamorph of *Mycosphaerella tassiana* (de Not.) Johans. (von Arx, 1950, 1983; Barr, 1958; Corlett, 1988). Barr (1958) believed the binomials *C. herbarum* and *C. macrocarpum* to be based on a variable anamorph and Corlett (1988) found an anamorph closer to *C. macrocarpum* than *C. herbarum* in association with the teleomorph *M. tassiana*.

During the process of conidiogenesis in *C. colocasiae* and *C. oxysporum*, as a prelude to conidiation, conidiophores become temporarily determinate. That is, linear apical growth ceases. The conidiophores swell appreciably at the extreme apex and a sequence of usually one to four or, more rarely five, ramo-conidia are formed in close proximity to one another at the surface of the inflated portion. Following such conidiation, apical meristematic terminal growth resumes giving rise, initially, to a narrow, hypha-like extension above the fertile node (see Plate 1, C; Figure 2). This grows to varying lengths, depending upon growing conditions, and eventually assumes the morphology of the subtending portion of the conidiophore. The extended distal portion usually becomes separated from the node below by a transverse septum and then ceases growth. Terminal swelling and conidiation then ensue at the higher level and the sequence of events is repeated a number of times to give rise to the characteristically nodose morphology.

The morphology of *C. oxysporum*, as is the case in many other species of *Cladosporium*, varies somewhat depending upon growth conditions. Appreciable differences occur in morphology of conidiophores in nature as compared to that of those produced *in vitro* on agar media. *In vivo*, the conidiophores tend to be shorter, more robust and pigmented, and thicker-walled than in culture. Also, the swellings along the conidiophore are usually closer together and more numerous in nature than *in vitro*. In fact, some conidiophores produced in nature are closely nodose along much of their length. Close spacial succession of fertile, intercalary nodes probably reflects lower nutrient availability and lower humidity levels in nature as opposed to in culture. Ramo- and intercalary conidia are generally septate in nature, whereas *in vitro* ramo-conidia are rarely septate and intercalary conidia are almost invariably non-septate. *Cladosporium*

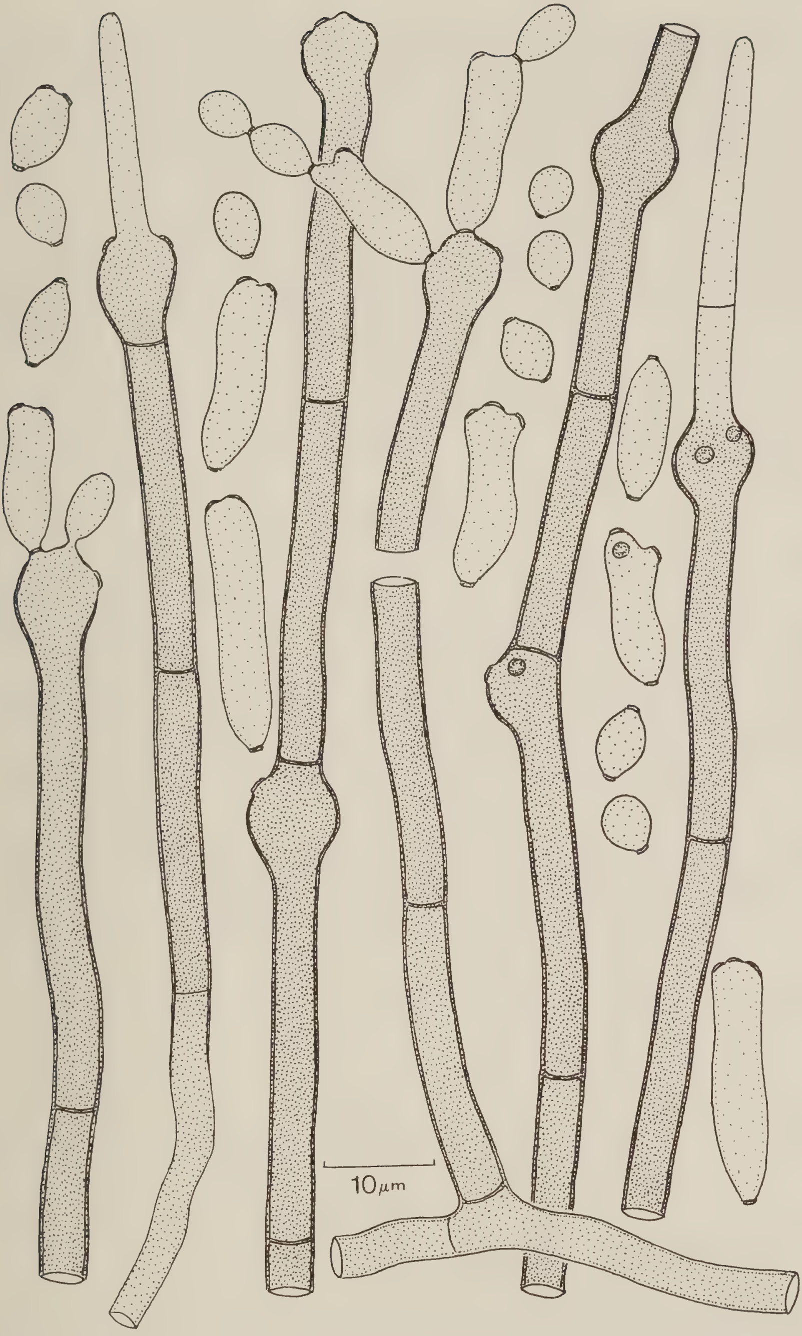


FIGURE 2. *Cladosporium oxysporum in vitro.* Conidiophores and conidia from culture.

oxysporum bears some resemblance to *C. chlorocephalum* (Fres.) Mason & M.B. Ellis, *C. geniculatum* Morgan-Jones and *C. sphaerospermum* Penz. with respect to morphology and, particularly, shape of its terminal conidia. These four species possess subglobose to globose terminal conidia. *Cladosporium geniculatum* differs from the other species in having larger, more pigmented conidia. Those of *C. sphaerospermum* are verrucose (Ellis, 1971), whereas the conidia of *C. oxysporum* are smooth. Apart from these differences, the taxa can be easily distinguished by the morphology of their conidiophores. The *Periconia*-like macroconidiophores of *C. chlorocephalum* are very distinctive (see McKemy and Morgan-Jones, 1991), as are the geniculate ones of *C. geniculatum* (see Morgan-Jones and Jacobsen, 1988). The frequently long, narrow ramo-conidia of *C. sphaerospermum* also serve to distinguish that species, and its conidiophores are usually appreciably shorter than those of *C. oxysporum*.

Cladosporium oxysporum colony morphology and coloration vary very little at different growth temperatures. When grown on PDA at 25C colony coloration changes abruptly after seven days as a result of the advent of prolific conidiation.

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COMPUTER CODING OF STRAIN FEATURES OF THE SAPROLEGNIAN FUNGI

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ABSTRACT

Saprolegnian fungi are the best known and most widely distributed of the water molds and are important in systematic, ecological, physiological, and biochemical research and teaching. A coding system that was developed for computer storage and analysis of microbial strain data has been expanded to include strain features specifically applicable to the identification of saprolegnian fungi.

BACKGROUND AND DISCUSSION

There are three basic types of living things in our environment from the point of view of ecological relationships: producers, consumers, and decomposers. The producers have chlorophyll or chemosynthetic pigments that, along with sunlight, are used to manufacture organic substances from inorganic materials thereby providing for the needs of the other groups. The consumers digest the organic substances provided by the producers and discard the indigestible materials. The decomposers destroy the products from the activities of both producers and consumers and ensure the return of the original inorganic elements into the cycle of matter, enabling the producers to again produce new organic substances.

Fungi depend on the elaborated organic substances as food sources and reduce them to the inorganic elements;

therefore, they are decomposers or scavengers. They are abundant everywhere decaying organic substances are found. The principal reservoirs of fungus populations in nature are water and soil. It has long been recognized that the most primitive fungi probably evolved in water. As their morphology and nutritional requirements became more complex, they migrated into the soil where their natural habitats diversified. Some of these soil fungi appear to have returned to the water in response to availability of nutrients in polluted and sewage waters (Sparrow, 1960).

The best known and most widely distributed water molds are members of the saprolegnian fungi. Most of them will grow readily in pure culture. Investigations of populations of saprolegnian fungi in natural environments involve the isolation, characterization, and identification of large numbers of strains (Coker, 1923). Data associated with these strains are of importance to systematic, ecological, physiological, and biochemical research and teaching. The needs for computerizing these data are now well recognized by both scientific and industrial communities.

Genera of saprolegnian fungi are distinguished by their asexual reproductive apparatus. Features of zoosporangium production and mode of zoospore release are also important for delimiting the genera. Species are distinguished primarily by their sexual reproductive organs (Dick, 1969, 1973; Johnson, 1956; Scott, 1961; Seymour, 1970). However, species of the saprolegnian fungi are often difficult to identify. There is a great need for a protocol that combines all previously described features that have been found to be important in the identification of saprolegnian fungi to species level.

The Microbial Information System (MICRO-IS) is a comprehensive system of computer programs for storage, management, and analysis of data on microbial strains (Krichevsky, 1987). MICRO-IS has been used by the staff of the American Type Culture Collection (ATCC) in collaborative efforts with other microbiologists to share information resources. MICRO-IS enables the investigator to enter data on a new strain and use the computer to aid identification by use of probability calculations. The identification program analyzes a matrix of the frequency of occurrence of each feature within each taxon to find the "best fit". Even when computer analysis does not give a positive identification, the results reduce the number of species that have to be considered and may suggest additional tests that can be performed to improve the identification. If multiple organisms are indicated, research into specific literature may be needed. This is less time consuming and more accurate than doing the whole process manually.

Features of individual strains are encoded for MICRO-IS using the RKC Coding system. The RKC Code (after the original authors -- Rogosa, Krichevsky, and Colwell, 1971) is a statement-oriented controlled vocabulary of descriptors of strain features in which an unique six-digit code number is assigned to each feature of an individual microbial strain. The Code currently includes more than 12,000 features descriptive of bacteria, algae, protozoa and some fungi (Rogosa *et al*., 1971; von Valkenburg *et al*., 1977, Daggett *et al*., 1980; Philpot *et al*., 1982). The expanded and revised RKC Code is now available in book form (Rogosa *et al*., 1986). Recently, the Code was further expanded to include characteristics of yeasts and the fungal genus *Phytophthora* (Jong *et al*., 1988, 1989).

In this communication, we present a set of characteristics that have been developed for use in identification of saprolegnian fungi. New features added to the RKC Code specifically for the saprolegnian fungi are marked with an "*" in the list below. The features include both the qualitative morphologic characters and the size of vegetative hyphae, zoosporangia, zoospores, chlamydospores, oogonia, oospores, and antheridia as well as the presence and relative abundance of these structures. The terms used for morphological descriptors are based on the descriptions given in Hawksworth *et al*. (1983).

ASEXUAL REPRODUCTION

- Sporangia

008173: Asexual spores (sporangiospores) are produced in sporangia (spore vesicles).
008539: Sporangia are on sporophores (sporangiophores).
008566: Sporangia occur singly.
008567: Sporangia occur in clusters.
008568: Sporangia occur in rows.
008569: Sporangia are produced acropetally.
008570: Sporangia are produced laterally.

008779: Sporangia are produced on agar medium.
008780: Sporangia are produced evenly on agar medium.
008781: Sporangia are produced in water.
008782: Sporangia are produced in liquid growth medium.
008809: Sporangia proliferate internally.
008810: Sporangia proliferate externally.
008811: Sporangia are terminal.
008812: Sporangia are intercalary.
008800: Sporangia have papillae.
008801: Sporangium has one papilla.
008802: Sporangium has two papillae.
008803: Sporangium has three papillae.
008826: Sporangia have appendages.
008549: Sporangia are apiculate.
008551: Sporangia are clavate (club-shaped).
008552: Sporangia are cylindrical.
008554: Sporangia are fusiform.
008558: Sporangia are spherical (length to breadth ratio is 1.0-1.05).
008966: Sporangia are broadly ellipsoidal (length to breadth ratio is 1.16-1.30).
008774: Sporangia are ellipsoidal (length to breadth ratio is 1.31-1.6).
008773: Sporangia are ovoid (egg-shaped, attached at broad end).
008816: Sporangia are obovoid (egg-shaped, attached at narrow end).
008818: Sporangia are pyriform (pear-shaped, attached at narrow end).
008819: Sporangia are obpyriform (pear-shaped, attached at broad end).
008817: Sporangia are limoniform (lemon-shaped, citriform).
008557: Sporangia are pod-like.
008555: Sporangia are irregular in shape.
008828: Sporangia are hyaline.
008563: Sporangial walls are smooth.

- Sporangial Dimensions

008571: Sporangia are 1.0-2.0 μ long.
008572: Sporangia are 2.1-5.0 μ long.
008573: Sporangia are 5.1-10 μ long.
008574: Sporangia are 11-15 μ long.
008575: Sporangia are 16-20 μ long.
008576: Sporangia are 21-30 μ long.
* 008981: Sporangia are 31-40 μ long.

* 008982: Sporangia are 41-50 μ long.
008838: Sporangia are 51-60 μ long.
008839: Sporangia are 61-70 μ long.
008840: Sporangia are 71-80 μ long.
008841: Sporangia are 81-90 μ long.
008842: Sporangia are 91-100 μ long.
008843: Sporangia are > 100 μ long.
008578: Sporangia are 1.0-2.0 μ wide.
008579: Sporangia are 2.1-3.0 μ wide.
008580: Sporangia are 3.1-4.0 μ wide.
008581: Sporangia are 4.1-5.0 μ wide.
008582: Sporangia are 5.1-10 μ wide.
008583: Sporangia are 11-15 μ wide.
008584: Sporangia are 16-20 μ wide.
008585: Sporangia are 21-30 μ wide.
008844: Length to breadth ratio of sporangium is < 1.6.
008845: Length to breadth ratio of sporangium is 1.6-1.9.
008846: Length to breadth ratio of sporangium is > 1.9.

- Sporangial Exit Pore Dimensions

008847: Exit pores of sporangia are 5-7 μ wide.
008848: Exit pores of sporangia are 8-10 μ wide.
008849: Exit pores of sporangia are > 10 μ wide.
008850: Length to breadth ratio of exit pore is < 0.2.
008851: Length to breadth ratio of exit pore is 0.2-0.3.
008852: Length to breadth ratio of exit pore is > 0.3.

- Zoospores

008752: Zoospores (motile spores) are produced.
008607: Zoospores are spherical.
008608: Zoospores are cylindrical.
008609: Zoospores are 0.1-1.0 μ long.
008610: Zoospores are 1.1-2.0 μ long.
008611: Zoospores are 2.1-3.0 μ long.
008612: Zoospores are 3.1-4.0 μ long.
008613: Zoospores are 4.1-5.0 μ long.
008614: Zoospores are 0.1-1.0 μ wide.
008615: Zoospores are 1.1-2.0 μ wide.
008616: Zoospores are 2.1-3.0 μ wide.
* 008983: Zoospores are monoplanetic (monomorphic; only one type of zoospore (primary zoospores) produced and only one swarm period occurs).

* 008984: Zoospores are diplanetic (dimorphic; two types of morphologically distinct zoospores (primary and secondary zoospores) produced at separate stages (swarm periods)).
* 008985: Zoospores are polyplanetic (secondary zoospores undergo repeated cycles of encystment and excystment).
* 008986: Zoospores are formed in a single row in the sporangium.
* 008987: Zoospores are formed in a single row in the evacuation tube.
* 008988: Zoospores germinate within sporangia by germ tubes which penetrate sporangial walls.
008194: Sporangial walls are loose and clearly separated from spores.
008853: Zoospores of sporangia are released.
008858: Sporangia collapse after zoospore release.
008859: Sporangia collapse partially after zoospore release.
008854: Zoospores of sporangia are released naked (unencysted).
* 008989: Zoospores encyst after release from sporangia.
* 008990: Zoospores encyst within sporangium.
* 008991: Zoospores encyst at mouth of sporangium.
008860: Zoospores emerge repeatedly from cysts.
* 008992: Zoospores emerge separately from cysts, leaving nets of empty cysts.

- Zoospore Flagellation

* 013381: Zoospores have flagella.
* 013382: Zoospores are biflagellate.
013018: Flagellum (or flagella) is inserted frankly laterally (from middle of cell).
* 013383: Insertion of flagellum (or flagella) is anterior (end that leads while swimming).
013352: Insertion of flagellum (or flagella) is posterior (end that trails while swimming).
* 013384: Whiplash flagella (lacking obvious scales or mastigonemes) are produced.
* 013385: Tinsel flagella (bearing mastigonemes) are produced.
* 013386: Anterior flagella are of whiplash type.
* 013387: Anterior flagella are of tinsel type.
* 013388: Posterior flagella are of whiplash type.
* 013389: Posterior flagella are of tinsel type.

* 013390: Lateral flagella are of whiplash type.
* 013391: Lateral flagella are of tinsel type.

- Chlamydospores

008363: Chlamydospores are present.
008421: Chlamydospores are terminal.
008422: Chlamydospores are intercalary.
* 008993: Chlamydospores occur singly.
* 008994: Chlamydospores are catenulate (in chains).
* 008995: Chlamydospores are filiform (thread-like).
* 008996: Chlamydospores are spherical.
* 008997: Chlamydospores are clavate (club-shaped).
* 008998: Chlamydospores germinate to produce hyphae.
* 008999: Chlamydospores germinate to produce short-stalked zoosporangia.

SEXUAL REPRODUCTION

008617: Sexual reproduction occurs.
008618: Strain is homothallic (both mating types on same mycelium).
008619: Strain is heterothallic (mating types on separate mycelia).
008620: Gametangia are formed.
008621: Gametangia are morphologically similar to vegetative hyphae (no sexual differentiation).
008622: Male gametangia are produced.
008623: Male gametes are produced.
008625: Female gametangia are produced.
008626: Female gametes are produced.
* 043001: Male and female gametangia are morphologically distinct.

- Antheridia

008880: Antheridia are present.
* 043002: Antheridia are androgynous (on same hypha as oogonium).
* 043003: Antheridia are hypogynous (directly under oogonium on same hypha).
* 043004: Antheridia are exigynous (arise directly from oogonial cell).
* 043005: Antheridia are monoclinous (on oogonial stalk).

* 043006: Antheridia are diclinous (not on same hypha as oogonium).
* 043007: Antheridia are laterally appressed to oogonial walls.
* 043008: Antheridia are apically appressed to oogonial walls.
* 043009: Antheridia are attached to oogonial wall by finger-like projections.
008890: Antheridia twist around oogonial stalks.
008891: Antheridia are hidden in knots of hyphae.
008895: Antheridia are unicellular.
008886: Antheridia are inflated.
008887: Antheridia are contorted.
008888: Antheridia are lobed.
008889: Antheridia are branched.
008897: Antheridia are clavate (club-shaped).
008898: Antheridia are prolate spheroidal (length to breadth ratio is 1.06-1.15).
* 043010: Antheridia are tubular.
008892: Antheridia are < 12 μ long.
008893: Antheridia are 12-20 μ long.
008894: Antheridia are > 20 μ long.
008896: Antheridia are < 20 μ long.

- Oogonia

008899: Oogonia are present.
008912: Oogonia are observed in intraspecific pairings.
008913: Oogonia are observed in interspecific pairings.
008900: Oogonia occur singly.
008901: Oogonia are clustered around common point of origin.
008903: Oogonium has two antheridia.
008904: Oogonium has three antheridia.
008905: Surfaces of oogonia are smooth.
008906: Surfaces of oogonia are reticulate.
008907: Surfaces of oogonia are verrucose.
008908: Surfaces of oogonia are bullate.
008909: Surfaces of oogonia are wrinkled.
008910: Surfaces of oogonia are undulate.
* 043011: Surfaces of oogonia are pitted.
* 043012: Surfaces of oogonia are papillate.
* 043013: Surfaces of oogonia are spiny.
* 043014: Surfaces of oogonia are crenulate.
* 043015: Oogonia are thick-walled.
008911: Oogonia walls are unevenly thickened.
008902: Oogonia are pigmented.

008915: Oogonia are spherical (length to breadth ratio is 1.0-1.05).
* 043016: Oogonia are prolate spheroidal (length to breadth ratio is 1.06-1.15).
* 043017: Oogonia are broadly ellipsoidal (length to breadth ratio is 1.16-1.30).
* 043018: Oogonia are ellipsoidal (length to breadth ratio is 1.31-1.6).
* 043019: Oogonia are ovoid (egg-shaped, attached at broad end).
* 043020: Oogonia are obovoid (egg-shaped, attached at narrow end).
008914: Oogonia are pyriform (pear-shaped, attached at narrow end).
* 043021: Oogonia are doliform (barrel-shaped).
* 043022: Oogonia are navicular (boat-shaped; spindle-shaped with one end truncated).
* 043023: Oogonia are fusiform.
* 043024: Oogonia are apiculate.
* 043025: Oogonia are filiform (thread-like).
008916: Oogonia are < 35 μ in diameter.
008917: Oogonia are 35-45 μ in diameter.
008918: Oogonia are > 45 μ in diameter.
008919: Oogonia are < 40 μ in diameter.
008920: Oogonia are 40-60 μ in diameter.
008921: Oogonia are > 60 μ in diameter.

- Oospores

* 043026: Oospores are present.
* 043027: Oogonium has one oospore.
008922: Oospores are plerotic.
008923: Oospores are < 21 μ in diameter.
008924: Oospores are 21-30 μ in diameter.
008925: Oospores are 31-40 μ in diameter.
008926: Oospores are 41-50 μ in diameter.
008927: Oospores are > 50 μ in diameter.
* 043028: Oospores are centric (with one or two peripheral layers of small oil droplets completely surrounding the central ooplasm).
* 043029: Oospores are eccentric (with one large oil globule disposed on one side of the oospore and not entirely enclosed by the ooplasm).
* 043030: Oospores are subcentric Type I (with one layer of small oil droplets on one side of the ooplasm and two or three layers on the opposing side).

* 043031: Oospores are subcentric Type II (with two or three layers of small oil droplets on one side of the ooplasm).
* 043032: Oospores are subcentric Type III (with a single, circular layer of small oil droplets located eccentrically to the oospore wall).
* 043033: Oospores germinate to produce hyphae.
* 043034: Oospores germinate to produce germ hyphae terminated by zoosporangia.
* 043035: Oospores are formed parthenogenetically.

SOURCE OF ISOLATION AND PATHOGENICITY

002012: What was the specific source of isolation (e.g., kind of water, soil, etc., species and organ and tissue of plant, animal, etc.)?
016426: Strain is parasitic.
016093: Strain has not been cultivated free of living host cells (obligate parasite).

NOTE: Parasitism or pathogenicity must be demonstrated by direct test, NOT source of isolation.

* 039140: Strain is parasitic on animals.
* 039141: Strain is parasitic on fish.
* 039142: Strain is parasitic on amphibians.
* 039143: Strain is parasitic on roots of higher plants.
* 039144: Strain is parasitic on diatoms.
* 039145: Strain is parasitic on Phycomycetes.
* 039146: Strain is parasitic on marine algae.

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NOTES ON AND ADDITIONS TO NORTH AMERICAN MEMBERS OF THE HERPOTRICHIELLACEAE

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SUMMARY

A brief discussion of the value of ascospore septation and of octospory and polyspory of asci results in the genera *Acanthostigmella* and *Capronia* being accepted in the Herpotrichiellaceae. North American representatives of *Capronia* include eight new species: *C. apiculata*, *C. arctica*, *C. borealis*, *C. dryadis*, *C. epimyces*, *C. exigua*, *C. montana*, *C. populicola*. The new combinations *C. chlorospora* (Ellis & Everh.) Barr, *C. collapsa* (Mathiassen) Barr, *C. commonsii* (Ellis & Everh.) Barr, *C. episphaeria* (Peck) Barr, *C. minima* (Ellis & Everh.) Barr, *C. nigerrima* (Bloxam) Barr, *C. porothelia* (Berk. & Curtis) Barr are proposed. A dichotomous key is presented to aid in identification of species in *Capronia*.

The Herpotrichiellaceae is a family that is known by small sizes of superficial ascomata that usually bear short setae or protruding cells over the surface and often have a grayish brown or olivaceous peridium. The ostioles are usually periphysate and the upper part of the centrum is lined with short, downhanging periphysoids. Aparaphysate asci are oblong to saccate, often thickened at the apex, octosporous or polysporous. The ascospores are hyaline at first and usually become light dull brown, olivaceous brown or grayish brown; they may be one or several septate, with longitudinal septa formed at times.

Munk (1953) erected the family and (1957) accepted five genera: *Herpotrichiella*, *Didymotrichiella*, *Dictyotrichiella*, *Capronia*, *Berlesiella*. Barr (in Bigelow and Barr 1969) accepted *Berlesiella*, in 1972 recognized *Herpotrichiella* and *Capronia* and added *Polytrichiella* and in 1977 included *Acanthostigmella*. Luttrell (1973) suggested that *Berlesiella* and *Dictyotrichiella* should be united under *Capronia*. Von Arx and Müller (1975) accepted five genera also: *Herpotrichiella*, *Polytrichiella*, *Berlesiella, Dictyotrichiella, Capronia.* The genera proposed over the years, with their type species and distinguishing characteristics are summarized below.

Capronia sexdecemspora (Cooke) Sacc. has separate ascomata, polysporous asci and hyaline muriform ascospores.
Berlesiella nigerrima (Bloxam) Sacc. forms a basal stroma beneath gregarious ascomata that may form as locules in the stroma, octosporous asci and brown muriform ascospores.
Caproniella juniperi (Richon) Berlese was segregated for *Capronia*-like species with brown ascospores; the genus was not utilized since.
Acanthostigmella genuflexa v. Höhnel has pallid ascomata, setae and ascospores, octosporous asci and transversely septate ascospores.
Herpotrichiella moravica Petrak has separate ascomata, octosporous asci and brown transversely septate ascospores.
Didymotrichiella inconspicua Munk has separate ascomata, octosporous asci and oblong brown one-septate ascospores.
Dictyotrichiella pulcherrima Munk has separate ascomata, octosporous asci and brown, muriform ascospores.
Polytrichiella polyspora Barr has separate ascomata, polysporous asci and hyaline to brownish, transversely septate ascospores; species with scolecospores have been included.

Müller et al. (1987) discussed the criteria used and accepted only two genera, *Acanthostigmella and Capronia.* Barr (1987b) preferred to recognize five genera according to ascospore septation and octo- or polysporous asci. She recognized that separate, gregarious ascomata, ascomata grouped on a stromatic basal layer, and locules in stromatic tissues are specific rather than generic characteristics in this family as in others, for example some species of *Mycosphaerella*, and placed *Dictyotrichiella* as a synonym of *Berlesiella*. O. Eriksson and Hawksworth (1990) followed Müller et al. to accept only *Acanthostigmella* and *Capronia*. They included too *the extralimital Berkelella* and questionably *Pleomelogramma* and *Taphrophila* in the family. For the last-named, judging by the description and especially by setae whose apices are branched, *T. cornu-capreoli* Scheuer (Scheuer 1988) seems likely to be a member of the Dimeraceae rather than the Herpotrichiellaceae.

Different ascospore shapes and septation are features that are considered to be valid in a number of loculoascomycete families. Within the Herpotrichiellaceae, ascospores may be wide, broadly obovoid, oblong or ellipsoid, and form three or more transverse septa and usually one or more longitudinal septa in several cells. They may be narrow, obovoid, fusoid, oblong or cylindric, and form one to several transverse septa, at times a longitudinal septum in one or few cells. Because of the variability in septation within single collections of a species, this character cannot be the sole one used to separate genera in this family. Should future studies on anamorphs (Müller et al. 1987) offer additional separating characters, some genera whose species have particular ascospore shapes and septation may again be recognized.

The issue of octospory versus polyspory as a generic character requires more consideration. The great majority of ascomycetous fungi produce eight ascospores per ascus, the result of meiosis followed by mitotic division to provide eight nuclei around which ascospore initials form. Later nuclear divisions are usual within the developing ascospore. In a number of taxa, apparently no mitotic division takes place before initials are delimited, or one or more of the initials may abort, so that asci may contain one, two, four or more but less than eight mature ascospores. Such a situation evidently is genetically fixed in some taxa and is regarded as an integral part of the organism, e.g. in all of the Meliolaceae, in some of the Erysiphaceae. In taxa where other characteristics are in accord, specific rank may be given to those that have less than eight ascospores, e.g. in some species of *Gnomonia*. In other taxa, more than eight ascospores may develop, polyspory.

Polyspory occurs in different groups of ascomycetous fungi. One concern of systematists is the value assigned to this character state: Is it of generic or of specific importance? First, a precise definition is required. Apparent polyspory may be the result of different processes. The production within the ascus by budding of primary ascospores may result in secondary spores, conidia, ultimate cells, at times formed from intermediate cells as in species of *Tympanis* (Helotiales) (Ouellette and Pirozynski 1974). Other taxa in the Helotiales may become polysporous by budding, such as species of *Ascocoryne* (Christiansen 1963, Dennis 1956), *Claussenomyces* (Korf and Abawi 1971, Ouellette and Pirozynski 1974), *Rutstroemia* (Dennis 1978); octosporous species are also known in each genus. Several species of *Nectria* (Hypocreales) have polysporous asci following budding of the primary ascospores; *Scoleconectria and Thyronectria* have been separated for this reason (e.g. Booth 1959), but Rossman (1989) replaced these species into *Nectria*. *Rhamphoria pyriformis* (Fr.) v. Höhnel (Xylariales) frequently buds from ascospores (Müller and Samuels 1982). In all of these cases, apparent polyspory may be utilized at the species but not the generic level.

Apparent polyspory may also occur by disarticulation of septate ascospores within the ascus, which results in the formation of sixteen to many partspores. In the Hypocreales, *Hypocrea*, *Podostroma*, *Trichosphaerella* are partially defined by the separation of one-septate ascospores into 16 partspores, as is the case of *Melanopsammella* in the Sordariales. In several taxa with elongate, multiseptate ascospores, these may disarticulate within the ascus, e.g. in *Mycomedusiospora* (Sordariales), *Torrubiella*, *Dussiella*, *Myriogenospora*, some species of *Cordyceps*, (Clavicipitales). In none is this the sole criterion for generic separation, although it may be one of the criteria. Among Loculoascomycetes, *Westerdykella* and some species of *Preussia* (Pleosporales) have three-septate, disarticulating ascospores, part of the constellation of characters that defines a genus or species.

True polyspory, where additional mitosis or mitoses give rise to 16 or more ascospore initials and eventually mature ascospores, is where most of the problems lie. The classical polysporous genera of the Diatrypaceae, *Diatrypella and Cryptovalsa*, are generally accepted for species whose stromata, ascoma configuration, and anamorphs are similar to those of *Diatrype and Eutypa* respectively (see e.g., Glawe and Rogers 1984, Rappaz 1987). The specialists in these organisms are invited to determine if such separation is logical. Similarly, *Valsella* (Diaporthales) is usually accepted as the polysporous counterpart of *Leucostoma*, although Müller and von Arx (1973) synonymized the two, following Petrak (1923, 1940). Petrak had argued, not only that species in *Valsella* had counterparts in *Leucostoma*, but that these should be regarded as polysporous forms of the respective species. Kern (1957) and Hubbes (1960) reported that polyspory was a constant character in the specimens that they examined and cultured, that is that it was at least a character of specific value.

In several other nonlichenized Hymenoascomycetes, polyspory is accepted as of specific value in genera that may have octosporous representatives as well, or may have only polysporous representatives, as in the Pezizales, *Thecotheus* and the genera of the Theleboleae (Kimbrough 1966, Kimbrough and Korf 1967, Cain and Kimbrough 1969, Bezzerra and Kimbrough 1975). Sordariaceous genera such as *Arnium*, *Podospora*, *Schizothecium*, have both octosporous and polysporous species (e.g., Cain 1934, Lundqvist 1972). Nannfeldt (1975) did not accept polyspory as the sole character for separating genera in the Nitschkiaceae. In the Calosphaeriales, *Pleurostoma* is separated from *Erostella* (Barr 1985 as *Togninia*) chiefly because of polyspory, but one should question that separation.

Several Loculoascomycetes exhibit polyspory. In the Dothideales, *Sydowia* has been maintained separately from *Dothiora* for that reason (Barr 1972, 1987b, Froidevaux

1973, Sivanesan 1984). In the Pleosporales *Lizonia* includes a polysporous species once separated under *Pseudolizonia* (Döbbeler 1978). In the Melanommatales, a few species of *Delitschia* are polysporous (Luck-Allen and Cain 1975). In the Herpotrichiellaceae of the Chaetothyriales, *Capronia and Polytrichiella* have been recognized as polysporous genera having close affinities with *Berlesiella and Herpotrichiella* (Barr 1972, 1987b), or as Müller et al. (1987) advocate, polyspory is accorded only specific value.

The foregoing brief review summarizes the steps taken to convince myself on the validity or nonvalidity of polyspory as a generic character. Logically, it must be admitted that, no matter how convenient, polyspory cannot be utilized as the sole character state to separate genera that are otherwise similar and whose species are closely related. Polyspory does provide a valid criterion in the delimitation of species.

The evaluation of North American taxa that now are accepted to belong in *Capronia* led to the conclusion that only a few of these could be identified with described European species. Because of their inconspicuous nature, it is quite likely that many more species will be found. In the present contribution, several new species are described, some new combinations are proposed, and a key to those recognized is presented. *Acanthostigmella* is recognized to house nonpigmented or slightly pigmented, setose species, whose ascospores are transversely septate (Barr 1977, Barr and Rogerson 1983).

Capronia apiculata Barr, sp. nov. Figs. 1-3

Ascomata gregaria, collabentia 100-150 µm lata vel 75-100 µm alta, cellulae protrudentes praedita. Asci 35-45 x 12-16 µm bitunicati oblongi sexdecemspori. Paraphyses desunt. Ascosporae 32-45 x 3-3.5 µm fuscae dilutae fusoideae apiculatae 6-12 septatae fasciculatae. Insidens ramo *Betulae glandulosae* Michx., "USA: Alaska, Mt. McKinley Nat'l Park, Wonder Lake Campground, 25 Jun 1970," lecti W. B. et V. G. Cooke 43253, holotypus in NY depositus.

Ascomata gregarious on thin mycelium, collabent, 100-150 µm wide, 75-100 µm high, apex rounded, pore small; peridium brown, thin, with few protruding cells and short setae. Asci 35-45 x 12-16 µm, 16-spored. Ascospores 32-45 x 3-3.5 µm, light dull brown, long fusoid, ends apiculate, 6-12-septate, not constricted at septa; wall smooth; minutely guttulate; in fascicle in the ascus.

Known only from the type collection.

Ascospore shape is much as in *C. fungicola* Samuels & Müller (Samuels and Müller 1978), but ascospores there are shorter and ascomata are setose.

Capronia arctica Barr, sp. nov. Fig. 4

Ascomata solitaria vel gregaria globosa (75-)105-190(-225) µm diametro, cellulae protrudentes praedita. Asci 45-88 x 13.5-27 µm bitunicati saccati. Paraphyses desunt. Ascosporae 18-32(-45) x 6.5-9 µm cinereofuscae dilutae fusoideae 3-7 transversalibus et unum longitudinalibus septatae confertae. Insidens ramo *Salicis reticulatae* L., "Canada: Northwest Territories, Baffin I., Frobisher Bay, 1 Jun 1955," lectus R. T. Wilce, holotypus in NY depositus.

Ascomata separate to gregarious, globose, (75-)105-190(-225) µm diam; apex rounded; peridium narrow, dull brown pseudoparenchymatous cells, bearing scattered protruding darker cells near apex, on thin mycelium. Asci 45-88 x 13.5-27 µm, saccate, octosporous. Ascospores 18-32(-45) x 6.5-9 µm, light grayish brown, fusoid, 3-7-septate, one longitudinal septum in mid or most cells; wall smooth; homogeneous; crowded in the ascus.

On branches of *Salix reticulata*.

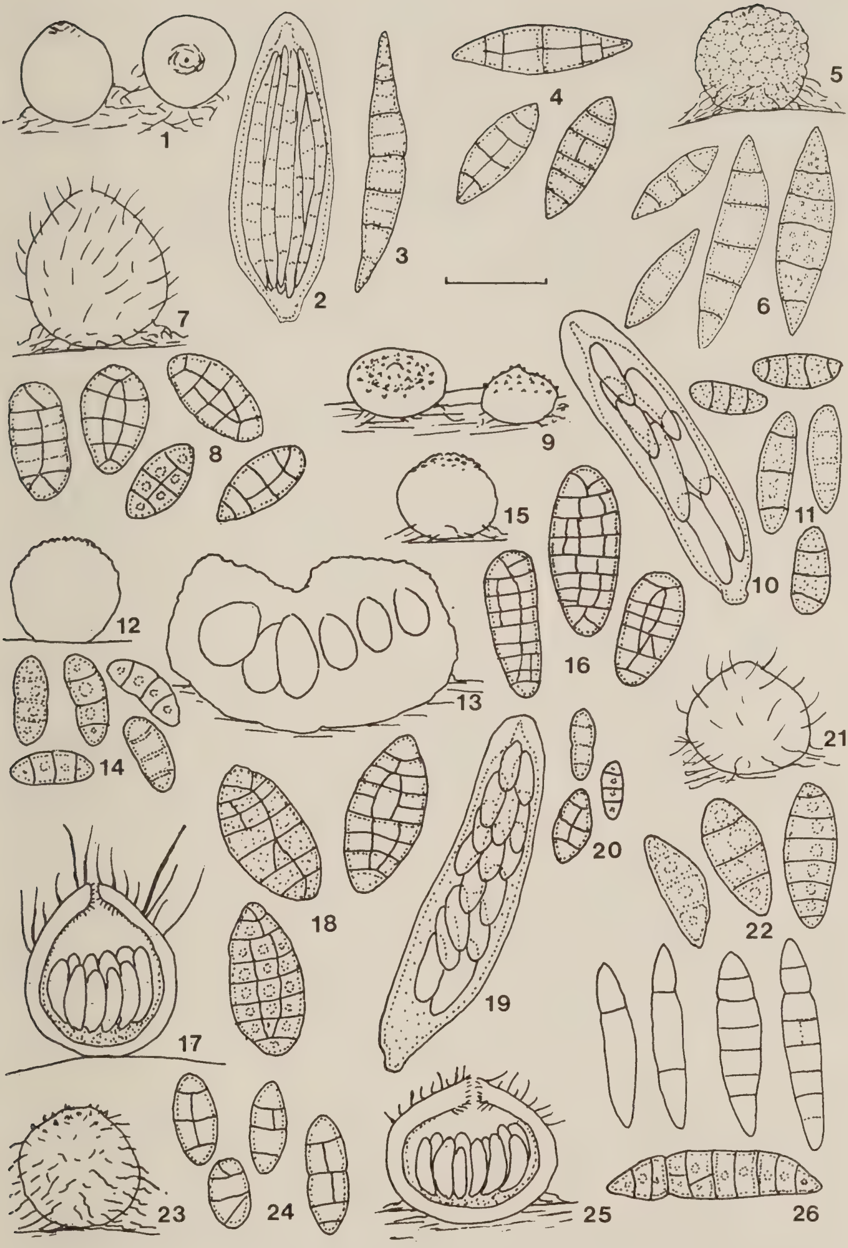
Additional collection examined. Newfoundland: Labrador, Hebron Fjord, 9 Jul 1954, R. T. Wilce (NY).

Capronia borealis Barr, sp. nov. Figs. 5-6

Ascomata solitaria vel gregaria globosa vel collabentia 100-150 µm lata 90-100 µm alta, ostiola pallida vel flava, cellulae protrudentes praedita. Asci (33-)39-60 x (11-)15-24 µm bitunicati ovoidei vel saccati octospori. Paraphyses desunt. Ascosporae (10-)15-27.5 x (3.5-)4.5-6 µm hyalinae vel olivaceofuscae dilutae fusoideae (1-3-)5-septatae confertae. Insidens caulo et ramo *Cassiope mertensianae* (Bong.) D. Don, "Canada: British Columbia, Garibaldi Prov. Park, 8 Aug 1952," lectus M. E. Barr 683, holotypus in NY depositus.

Ascomata separate to gregarious, globose collabent, 100-150 µm wide, 90-100 µm high, apical pore inconspicuous, pallid to yellowish; peridium grayish brown, narrow, roughened by protruding groups of dark brown cells, seated

Figs. 1-26. Species of *Capronia*. 1-3. *C. apiculata*: 1, outline of ascomata, 2, ascus, 3, ascospore. 4. *C. arctica*: ascospores. 5-6. *C. borealis*: 5, outline of ascoma, 6, ascospores. 7-8. *C. chlorospora*: 7, outline of ascoma, 8, ascospores. 9-11. *C. collapsa*: 9, outline of ascomata, 10, ascus, 11, ascospores. 12-14. *C. commonsii*: 12, outline of ascoma, 13, outline of stroma, 14, ascospores. 15-16. *C. dryadis*: 15, outline of ascoma, 16. ascospores. 17-18. *C. epimyces*: 17, ascoma in vertical section, 18, ascospores. 19-20. *C. exigua*: 19, ascus, 20, ascospores. 21-22. *C. montana*: 21, outline of ascoma, 22, ascospores. 23-24. *C. pleiospora*: 23, outline of ascoma, 24, ascospores. 25-26. *C. populicola*: 25, ascoma in vertical section. 26. ascospores, indicating sequence in development of septa. Standard line = 15 µm for asci and ascospores, 150 µm for ascomata and stroma.



on thin brown mycelium. Asci (33-)39-60 x (11-)15-24 µm, ovoid or saccate, octosporous. Ascospores (10-)15-27.5 x (3.5-) 4.5-6 µm, hyaline becoming light olive brown, fusoid, straight to inequilateral or curved, (1-3-) 5-septate, rarely longitudinal septum in one cell, not constricted at septa; wall smooth; guttulate; crowded in the ascus.

On woody stems and branches.

Additional collections examined. Canada: Quebec: *Taxus canadensis* Marsh., Mt. Albert, Gaspesian Prov. Park, 11 Jul 1957, M. E. Barr 2016 (NY). British Columbia: *Cassiope mertensiana*, Garibaldi Prov. Park, 5 Aug 1952, M. E. Barr 647 (NY). USA: Michigan: *Vaccinium angustifolium* Aiton, Cheboygan Co., Topinabee Oaks, 19 Jul 1953, M. E. Barr 999b (NY).

Although on quite disparate substrates, these collections seem to be so closely related that they comprise a single species. The ascomata with protruding groups of cells and the wide asci separate *C. borealis* from the other species that have similar ascospores, *C. fusispora* (Barr) Müller et al. and *C. montana* Barr. The type and second collection on *Cassiope* were identified originally as *C. fusispora* (Barr 1972) but are separable from that species.

Capronia chlorospora (Ellis & Everh.) Barr, comb. nov.
Figs. 7-8

Teichospora chlorospora Ellis & Everh. North Amer. Pyrenomyc. 219. 1892.

Pleosphaeria chlorospora (Ellis & Everh.) Sacc. Syll. Fung. 11: 347. 1895.

Ascomata separate, globose, 80-220 µm diam, apical pore minute, lined with short dark setae; peridium bright or dull brown, ca. 15 µm wide, setose over upper half, setae brown to blackish, one-celled, 25-65 µm long, some light brown hyphae below and on substrate. Asci 45-70 (-80) x 10-18 µm, oblong, often inflated, octosporous. Ascospores (11-)12-18(-20) x (5.5-)7-9 µm, dull grayish brown or olivaceous, ellipsoid, ends obtuse, 3-7-septate, longitudinal septum through mid cells, rarely into end cells, usually constricted at first septum; wall smooth; guttulate or globule in each cell; crowded biseriate in the ascus.

On decorted wood and loosened periderm, occasionally over other ascomycetes.

Collections examined. USA: Massachusetts: *Acer saccharum* Marsh, Franklin Co., Conway, Baptist Hill, 27 Mar 1968, M. E. Barr 5117; *Carya*, 11 Oct 1987, M.E.Barr 7126 (both NY). New Jersey: *Ailanthus*, Gloucester Co., Newfield, J. B. Ellis, 24 Mar 1893 (NY); *Acer*, Nov 1880 (NY, on Ellis NAF 580 of *Sphaeria microtheca*). Ohio: Morgan 1045 (NY as *Teichospora modesta?*). Arizona: *Lemaireocereus (Cereus) thurberi* (Scheidw.) Britton & J.

Rose, Organ Pipe Nat'l Monument, 30 Apr 1987, M.F. & P. J. Rohman (NY). Vermont: old *Hypoxylon* on *Fagus*, Lamoille Co., Stowe, Goldbrook Road, 13 Aug 1964, M. E. Barr 4517 (NY).

The holotype of *Teichospora chlorospora*, on *Quercus* wood, was not located, but these collections fit the description well, and the Ellis specimen on *Ailanthus* was determined by Ellis as *T. chlorospora*. *Capronia minima* is related but has collabent ascomata bearing very short setae or protruding cells and somewhat smaller ascospores.

Capronia collapsa (Mathiassen) Barr, comb. nov.
Figs. 9-11
Herpotrichiella collapsa Mathiassen, Sommerfeltia 9: 51. 1989.

Ascomata separate or somewhat gregarious, collabent, (90-)120-240(-385) µm wide, (60-)100-150(-275) µm high; apex minutely papillate, ostiole periphysate; peridium brown, (7.5-)15-30 µm wide, bearing scattered short or elongate setae, 12-35(80-130) µm and sparse brown hyphae toward base. Asci 45-65 x 9-12 µm, octosporous. Ascospores (10-)12-18 x 3.5-5.5 µm, grayish brown, ellipsoid or somewhat obovoid, ends obtuse, 3-septate, not constricted; wall smooth; granular; overlapping biseriate to triseriate in the ascus.

On old wood.

Collections examined. USA: California: *Populus trichocarpa* Torr. & A. Gray, Shasta Co., Manzanita Lake, Lassen Volcanic Nat'l Park, 12 Jul 1968, W. B. & V. G. Cooke 39384 (NY with *Glyphium elatum* and immature Helotiales); *Arctostaphylos patula* Greene, Manzanita Creek Trail, 13 Jul 1972, W. B. & V. G. Cooke 45611 (NY). Washington: *Vaccinium myrtilloides* Michx., Skamania Co., 'Mountains', 19 Jul 1894, W. N. Suksdorf, Flora Wash. 507 (NY).

The collection on *Vaccinium* has small collabent ascomata, 90-100 x 60-70 µm, and ascospores that are similar in shape and septation, 13-16.5 x 3.5-4.5 µm. The specimen is the holotype of *Trichopeziza coarctata* Ellis & Everh., which is immature and is considered to be a doubtful species (Seaver 1951). As Mathiassen (1989) observed, *C. collapsa* is evidently a collabent counterpart of the smaller *C. pilosella* (Karst.) Müller et al.

Capronia commonsii (Ellis & Everh.) Barr, comb. nov.
Figs. 12-14
Melanomma commonsii Ellis & Everh. Proc. Acad. Nat. Sci. Philadelphia 42: 239. 1890.

This species, whose ascomata are velvety with protruding cells and short setae over stromata of *Hypoxylon*, differs from *C. parasitica* (Ellis & Everh.) Müller et al.

in obovoid ascospores with obtuse ends. A collection on *Graphostroma platystoma* (Schwein.) Pirozynski (USA: Illinois: Carroll Co., Mississippi Palisades St. Park, 13 Apr 1983, D. A. Glawe 86-35, IL) has ascomata aggregated into small stromata; the short inflated asci and obovoid ascospores are identical to other collections of *C. commonsii*.

Capronia dryadis Barr, sp. nov. Figs. 15-16

Ascomata solitaria globosa circa 120 µm, cellulae protrudentes praedita. Asci 60-67 x 18-21 µm bitunicati ellipsoidei vel saccati octospori. Paraphyses desunt. Ascosporae 18-23.5 x 6.5-9 µm cinereofuscae obovoideae 7-8-(9-) transversalibus et 1-3 longitudinalibus septatae confertae. Insidens *Dryadi integrifoliae* Vahl pubescentiae, "Canada: Northwest Territories, Baffin Island, head of Clyde Inlet, 16 Jul 1950," lectus P. Dansereau 5007160857d, holotypus in NY depositus.

Ascomata separate in pubescence of peduncle, globose, ca. 120 µm diam; apex rounded, pore small; peridium light brown, narrow, dark brown around pore with protruding cells and short chains of cells. Asci 60-67 x 18-21 µm, ellipsoid to saccate. Ascospores 18-23.5 x 6.5-9 µm, grayish brown, obovoid, ends obtuse, 7-8-(9-)septate with one complete longitudinal septum and 2-3 in some cells, not constricted; wall smooth; homogeneous; crowded in the ascus.

Known only from the type collection.

Capronia epimyces Barr, sp. nov. Figs. 17-18

Ascomata gregaria vel solitaria globosa 80-200 µm diametro, setae vel cellulae protrudentia praedita, setae 26-120 µm longae. Asci (55-)65-88 x 17.5-24(-30) µm bitunicati oblongi vel saccati octospori. Paraphyses desunt. Ascosporae 18-27 x 7.5-12 µm cinereofuscae ellipsoideae 5-9- transversaliter et 1-2(-3) longitudinaliter septatae biseriatae vel confertae. Insidens *Nectriae* stromatibus in *Pini strobi* L., "USA: Massachusetts, Franklin Co., Conway, 19 Apr 1971," lectus M. E. Barr 5745, holotypus in NY depositus.

Ascomata gregarious or separate, globose, 80-200 µm diam; apex short papillate, ostiole lined with short setae; peridium brown, 12-20 µm wide, surface of dark protruding cells, 4.5-5.5 µm, interspersed with dark elongate, unicellular setae, 26-120 µm long, light brown hyphae below connecting to thin mycelium. Asci (55-)65-88 x 17.5-24(-30) µm, oblong saccate. Ascospores 18-27 x 7.5-12 µm, dull grayish brown, ellipsoid, tapered to obtuse ends, 5-9-septate, not constricted, 1-2(-3) longitudinal septa; wall smooth; granular or one globule per cell; overlapping biseriate or crowded in the ascus.

Gregarious on old *Nectria* stromata on *Pinus* or scattered on periderm.

Additional collections examined. USA: Wisconsin:

Dane Co., Madison, Arboretum, 5 Sep 1953, M. E. Barr 1527a (NY). Spain: *Pinus pinaster* Aiton, Coco (Segovia) 2 May 1985, P. Yebes & J. Checa 9280 dupl.(NY).

Capronia acutiseta Samuels (in Müller et al. 1987) was described on decorticated wood from New Zealand and has much in common with *C. epimyces*. In addition to the differing substrates, *C. epimyces* has longer setae, narrower asci and ascospores.

Capronia episphaeria (Peck) Barr, comb. nov.
Basionym: *Dothidea episphaeria* Peck, Ann. Rep. New York State Museum 30: 64. (for 1876) 1878.

Barr (1987a) transferred the species to *Berlesiella* as a nonsetose, stromatic, larger-spored entity than *B. nigerrima* (Bloxam) Sacc., where it was placed earlier (Bigelow and Barr 1969, Barr et al. 1986). Both taxa form locules in stromata that develop over diatrypaceous fungi. Figures 10 I and J in Barr (1987b) illustrate the differences in ascospores.

Capronia exigua Barr, sp. nov. Figs. 17-18

Ascomata vel stromata pauciloculata gregaria globosa 104-140 µm diametro, papillae pusillae; cellulae protrudentes praedita. Asci 40-50 x 10-11 µm, bitunicati oblongae sexdecemsporae. Paraphyses desunt. Ascosporae 8-10 x 3-4 µm olivaceocinereae oblongae vel obovoideae 3-transversalibus et unum longitudinalibus septatae confertae. Insidens *Yuccae* folio et in *Kellermania* conidiomatibus "USA: California, San Francisco State University Campus, Dec 1980," lectus H. E. Bigelow s.n., holotypus in NY depositus.

Ascomata superficial or in old conidiomata, gregarious and at times forming stromata with few locules, globose, 104-140 µm diam, apex very short papillate; peridium dull dark brown, narrow, ca. 15 µm, surface roughened by protruding cells especially toward apex. Asci 40-50 x 10-11 µm, 16-spored. Ascospores 8-10 x 3-4 µm, grayish olivaceous, ends pallid, oblong to obovoid, ends obtuse, 3-septate, longitudinal septum often in one or both mid cells, not constricted; wall smooth; guttulate; crowded in the ascus.

In leaf of *Yucca* and in old conidiomata of *Kellermania*. Known only from the type collection.

This is a small species, probably on other overmature fungi also mixed with the *Kellermania* conidiomata.

Capronia minima (Ellis & Everh.) Barr, comb. nov.
Basionym: *Teichospora minima* Ellis & Everh. Proc. Nat. Acad. Sci. Philadelphia 47: 419. 1895.

Barr (1990) made the combination into *Berlesiella* and provided a description and illustrations of the species. Several other collections of this collabent species are known, usually associated with old ascomata. *Apiosporium ? erysiphoides* Sacc. & Ellis (Michelia 1: 566. 1882) could arguably be the earlier name. An ascoma was illustrated in North American Pyrenomycetes (Ellis and Everhart 1892, Pl. 8, Fig. 6); otherwise, with no information on asci and ascospores it was termed a doubtful species. A later collection NAF 1232 (over valsoid stromata on *Magnolia glauca* L. (= *M. virginiana* L.), Newfield, N. J. Nov 1883) identified as *Apiosporium ? erysiphoides* can be referred to *C. minima*.

Collections examined. USA: Massachusetts: *Acer saccharum* over *Graphostroma platystoma*, Franklin Co., Conway State Forest, 29 Aug 1967, M. E. Barr 5044a (NY); *Populus tremuloides* Michx., Hampshire Co., Hadley, 5 Dec 1979, 22 Feb 1980 (as Barr 6701), H. E. Ahles (NY). Kansas: weathered pine, Rockport, Feb 1894, E. Bartholomew, NAF 3112 as *Melanomma sparsum (NY)*.

Capronia montana Barr, sp. nov. Figs. 21-22

Ascomata solitaria vel gregaria collabentia 100-200 µm lata 90-130 µm alta, papillae pusillae anthracinae, setae 15-44 µm longae praedita. Asci 47.5-80 x 11-16 µm bitunicati oblongi octospori. Paraphyses desunt. Ascosporae 15.5-21 x 5.5-6.5(-8) µm olivaceofuscae dilutae fusoideae (1-)3-4-(7-) transversalibus et unum longitudinalibus aliquando septatae confertae. Status anamorphosis ad *Exophialam* pertinens. Insidens ligno arboro conifero, "Canada: British Columbia, Garibaldi Prov. Park, 4 Aug 1952," lectus M. E. Barr 688a, holotypus in NY depositus.

Ascomata separate to gregarious on thin crust of olivaceous brown hyphae, collabent, 100-200 µm wide, 90-130 µm high, apex short papillate, shining black; peridium olivaceous brown, 10-12 µm wide, dark brown setae around sides and from basal crust, 15-44 µm long. Asci 47.5-80 x 11-16 µm, octosporous. Ascospores 15.5-21 x 5.5-6.5(-8) µm, light olivaceous brown, fusoid, ends acute, straight to inequilateral, (1-)3-4(-7) septate, at times longitudinal septum in one cell, not or slightly constricted; wall smooth, one globule per cell; crowded in the ascus. *Exophiala* anamorph: Conidiophores from basal crust, simple or branched, conidiogenous cells integrated or terminal, holoblastic; conidia 3.5-4.5 x 2-2.5 µm, grayish brown, ellipsoid, one celled.

On old conifer wood.

Additional collection examined. USA: *Pinus contorta* Douglas ex Loud., Idaho: Bonner Co., Sec. 11,T16N R5W, 9 Jun 1940, A. W. Slipp 690 (part NY).

Capronia montana is related to *C. fusispora* (Barr) Müller et al., where ascomata are globose, and *C. borealis* where ascomata are collabent but asci are wider.

Capronia nigerrima (Bloxam) Barr, comb. nov.
Basionym: *Sphaeria nigerrima* Bloxam ex Currey, Trans. Linn. Soc. London 22: 272. 1858.

This species was re-described in Bigelow and Barr (1969) under *Berlesiella*, where my concept then included the glabrous, larger-spored *C. episphaeria*. Collections of *C. nigerrima* typically have short setose, crowded ascomata over the surface or are sunk as locules in a stromatic base, and ascospores 12-18 x 5-6.5 µm. Specimens in NY labelled with the unpublished herbarium name *Dearnessia canadensis* Ellis & Everh. are this species. The combination into *Capronia* is proposed here, for although Müller et al. (1987) mentioned "*C.*" *nigerrima*, they did not make the formal disposition, nor have I found that it has been made elsewhere.

Capronia pleiospora (Mouton) Sacc. Figs. 23-24

A North American collection that agrees well with Munk's (1957) description has setose ascomata, 16-spored asci and ascospores 13-16 x 6-7 µm [on *Lonicera ciliosa* (Pursh.) Poir., Canada: British Columbia, Sidney, 29 Jul 1990, M. E. Barr 7235, DAOM].

Capronia populicola Barr, sp. nov. Figs. 25-26

Ascomata solitaria collabentia 245-275 µm lata 190-220 µm alta, papillae pusillae, setae 15-20 µm longae protrudentia praedita. Asci 70-100 x 14-18 µm bitunicati oblongi octospori. Paraphyses desunt. Ascosporae 25-36 x 6-7 µm fuscae dilutae fusoideae (4-)8-(9-11-) transversalibus et unum longitudinalibus septatae, ad septum supramedium constrictae, biseriatae vel triseriatae. Insidens *Populi balsamiferae* L. peridio, "USA: Massachusetts, Franklin Co., Baptist Hill, Conway, 9 Dec 1979," lectus M. E. Barr 6640, holotypus in NY depositus.

Ascomata separate, collabent, 245-275 µm wide, 190-220 µm high; apex short papillate, ostiole periphysate; peridium dark brown, ca. 20 µm wide, short setose over much of surface, setae black, 15-20 µm long, brown hyphae from lower sides. Asci 70-100 x 14-18 µm. Ascospores 25-36 x 6-7 µm, hyaline becoming light brown, fusoid, ends acute, inequilateral or slightly curved, (4-)8-(9-11-) septate, finally longitudinal septum in 1-3 mid cells, constricted at first-formed, supramedian septum, at times at second septum; wall smooth; one globule per cell; overlapping biseriate to triseriate in the ascus.

On old periderm of *Populus balsamifera*. Known only from the type collection.

This species is similar in most aspects to *B. fungicola* Samuels & Müller (Samuels and Müller 1978) which has smaller ascospores 17-25 x 3-5 µm with 5-7 septa. *Herpotrichiella longispora* Remler (Remler 1979) has similar ascomata and asci but longer, narrower ascospores, 39.5-64.5 x 4-6.5 µm.

Capronia porothelia (Berk. & Curtis) Barr, comb. nov.
Basionym: *Sphaeria porothelia* Berk. & Curtis, Grevillea 4: 142. 1876.

Barr (1976) redescribed the species under *Herpotrichiella porothelia* (Berk. & Curtis) Barr. Müller et al. (1987) suggested that it was likely to be identical with *C. spinifera* (Ellis & Everh.) Müller et al. Narrower, oblong asci and slightly smaller ascospores separate *C. porothelia* for the present.

Key to North American Species of *Capronia*

1. Ascospores relatively wide, 2-2.5:1, broadly oblong, obovoid or ellipsoid, almost always with longitudinal septum in one or more cells..............................2
1. Ascospores relatively narrow, (2.5-)3-4: 1 or narrower, obovoid, fusoid, oblong or cylindric, with or lacking longitudinal septum..............................8
2. Asci octosporous..............................3
2. Asci polysporous..............................6
3. Ascospores 18-27 µm long; ascomata globose..........4
3. Ascospores (9-)10-18(-20) µm long; ascomata globose or collabent..............................5
4. Ascospores obovoid, 18-23.5 x 6.5-9 µm, 7-8-(9-)septate; ascomata bearing protruding cells, in pubescence..............................*C. dryadis*
4. Ascospores more ellipsoid, 18-27 x 7.5-12 µm, 5-9-septate; ascomata bearing setae, gregarious over hypocreaceous stromata on conifers........*C. epimyces*
5. Ascospores (9-)10-15.5 x 4.5-7.5 µm, (1-)3-7-septate; ascomata collabent, bearing protruding cells or short setae, gregarious on wood or periderm, often over other ascomycetes..............................*C. minima*
5. Ascospores (11-)12-18(-20) x (5.5-)7-9 µm, 3-7-septate; ascomata globose, bearing setae; separate to gregarious on old wood..............................*C. chlorospora*
6. Ascospores 8-10 x 3-4 µm, 3-septate; ascomata bearing protruding cells; on and in *Kellermania* condiomata among other fungi on *Yucca*..........*C. exigua*
6. Ascospores larger..............................7
7. Ascospores 13-16 x 6-7 µm, 3-(4-)septate; ascomata setose, on wood..............................*C. pleiospora*
7. Ascospores 15-22.5 x 5-9 µm, 3-6-(7-)septate; ascomata bearing protruding cells..................*C. irregularis*
8. Asci octosporous..............................9
8. Asci polysporous..............................22
9. Ascospores 18-45 x 6-9 µm..............................10
9. Ascospores shorter or narrower if reaching 27 µm 11
10. Ascospores 25-36 x 6-7 µm, (4-)8-(11-)septate; ascomata collabent, setose.............*C. populicola*

10. Ascospores 18-32(-45) x 6.5-9 µm, 3-7-septate; ascomata globose, bearing protruding cells.. *C. arctica*

11. Ascospores 9-14 µm long, 3-septate..................12

11. Ascospores (10-)12-24(-27) µm long, septation variable...14

12. Ascospores fusoid with acute tips, 9-13 x 3.5-4.5 µm; ascomata short setose, over ascomycete stromata.. *C. parasitica*

12. Ascospores obovoid with obtuse tips, 10-14 µm long; ascomata short setose or bearing protruding cells...13

13. Ascospores 3-4 µm wide in narrow asci; over basidiomycete hymenium............................ *C. porothelia*

13. Ascospores 3.5-5 µm wide in inflated asci; over ascomycete stromata............................ *C. commonsii*

14. Ascospores obovoid, inequilateral, 3-7-septate with one longitudinal septum; ascomata usually gregarious or immersed in stromatic base over diatrypaceous ascomycetes..................................15

14. Ascospores oblong, fusoid or somewhat obovoid, 1-3-5-septate, rarely longitudinal septum in one cell; ascomata usually separate........................16

15. Ascospores 12-18 x 5-6.5 µm, 3-5-septate; ascomata short setose.................................. *C. nigerrima*

15. Ascospores 16.5-24 x 6-7.5 µm, 5-7-septate; ascomata lacking setae.............................. *C. episphaeria*

16. Ascospores oblong obovoid, ends obtuse.........17

16. Ascospores fusoid, ends acute..................20

17. Ascomata collabent, short setose; ascospores (10-)12-18 x 3.5-5.5 µm............................... *C. collapsa*

17. Ascomata globose, short setose or bearing protruding cells...18

18. Ascomata bearing protruding cells or minute setae; ascospores (10-)13-15.5 x 3.5-4.5 µm; in old basidiomycetes.......................... *C. spinifera*

18. Ascomata setose, over decorticated wood or arctic-alpine on stems..............................19

19. Ascospores 11-15.5 x 3.5-6 µm; on decorticated wood.. *C. pilosella*

19. Ascospores 15-21 x 3-5 µm; arctic-alpine on stems.. *C. setosa*

20. Ascomata globose, setose; ascospores 13.5-20(-27) x 3-5 µm................................. *C. fusispora*

20. Ascomata collabent, setose or bearing protruding cells...21

21. Ascomata setose; ascospores 15.5-21 x 5.5-6.5(-8) µm in relatively narrow asci, 47-80 x 11-16 µm..... *C. montana*

21. Ascomata bearing protruding cells; ascospores (10-)15-27.5 x (3.5-)4.5-6 µm in shorter, wider asci (33-)39-60 x (11-)15-24 µm.................................. *C. borealis*

22. Ascomata globose, setose; ascospores 9-18 x 3-4.5(-7) µm, 1-3-septate.................. *C. polyspora*

22. Ascomata collabent, setose or bearing protruding

cells; ascospores longer..........................23

23. Ascomata bearing protruding cells; ascospores 32-45 x 3-3.5 µm, 6-12-septate........................*C. apiculata*

23. Ascomata setose; ascospores narrower, 1-2(-2.5) µm, 1-7-septate...24

24. Ascospores 17.5-27.5 x 1-2(-2.5) µm, 1-septate.....................................*C. albimontana*

24. Ascospores 46-60 x 1.5-2(-2.5) µm, (3-)5-7-septate....................................*C. longispora*

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MYCOTAXON

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IN VITRO SYNTHESIS OF ECTOMYCORRHIZAE BETWEEN *SUILLUS COLLINITUS* (FR.) O. KUNTZE AND *RHIZOPOGON ROSEOLUS* (CORDA) TH. M. FR. WITH *PINUS HALEPENSIS* MILLER

by

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Suillus collinitus and *Rhizopogon roseolus* are two ectomycorrhizal species commonly found in forests of *Pinus halepensis* in Southern Spain (HONRUBIA & LLIMONA, 1983; HONRUBIA et al., 1982). Carpophores of these species have been collected each of several years in plantations of *P. halepensis* of different ages. Both appear to be well adapted to xeric conditions of this mediterranean region and are potentially useful in inoculation programs for *P. halepensis*. It is therefore essential to verify the association between these fungi and the putative symbiotic tree species and the "in vitro" synthesis of ectomicorrhizae is the first step (PALM & STEWART, 1984). In this work we have isolated *S. collinitus* and *R. roseolus* in pure culture and have experimentally confirmed the formation of ectomycorrhizae with *P. halepensis*.

The morphology and anatomy of the most common ectomycorrhizae of this species from Israel were described by WAHL (1950) and WAHL & REICHERT (1955) . They also described the production of mycorrhizae on seedlings of *P. halepensis* after inoculation with mycelium obtained in pure culture from *Suillus granulatus* in sterile soil. TRAPPE (1962) cited this fungal species as the only symbiont of *P. halepensis*.

Few later studies mention mycorrhizal formation in *P. halepensis* (PALENZONA et al., 1972; GAY et al., 1982; RUEHLE et al., 1981; CHEVALIER & DETOLLE, 1984).

Pure culture isolates were obtained by placing small pieces of pileus tissue from *S. collinitus* and glebal tissue from *R. roseolus* in Petri dishes with Modified-Melin-Norkrans agar (MMN) (MARX, 1969). Isolates were grown in darkness at 23ºC and successive subcultures were also made in MMN. At the same time, seeds of *P. halepensis* were sterilized in 30% H_2O_2 for 15 minutes and sown in trays of sterile sand. The root systems of the seedlings were kept under observation until the short roots appeared. Seedlings were immediatly transferred to growth pouches (FORTIN et al., 1980).

From the edge of the colonies small square pieces (5mm) of mycelium were taken and placed in MMN liquid. These pieces were then transferred to the pouches containing the 3 month old seedlings with their short roots (according to the method described by FORTIN et al., 1980, and modified by S. Miller, *in litt.*).

The pouches were placed in a culture chamber with an average temperature of 22ºC and photoperiod of 16 hours light/8 hours darkness.

Once the mycorrhizae were synthesized the most representative structures were selected and fixed in FAA (1:5:1). Semifine (15µm) sections were then made in paraffin without staining for observation in phase-contrast-microscope.

The mycelia obtained after isolation in MMN is described as follows:

Suillus collinitus : mycelium initially white, then greyish brown, superficial, clearly defined margin, lobulated, with dark brown reverse side.

Rhizopogon roseolus : mycelium initially cream then reddish brown, with abundant mycelial strands, irregular margin with reddish brown reverse.

Description of ectomycorrhizae

Suillus collinitus + *Pinus halepensis* (fig.1)

Morphological characteristics: simple dichotomies, sessile or stiped, in some cases branched, white initially and finally cream, 3-4 mm in length and 400-500 µm in diameter. Smooth surface with extramatrical hyphae between the dichotomies sometimes forming mycelial strands but not rhizomorphs.

Anatomical characteristics in section: well developed mantle of prosenchymatous (felt prosenchyma, ss. CHILVERS, 1968), 40-100 µm wide, formed by hyphae of 2.5-3.75 µm diameter, with clamp connections; near the host tissue, the hyphae form a parenchymatous tissue. The mantle surface is formed of lax hyphae; no type of ornamentation appears. The Hartig net is very branched and penetrates as far as the endodermis (hyphae 4.5-5 µm in diameter).

Rhizopogon roseolus + *Pinus halepensis* (fig.2)

Morphological characteristics: simple dichotomies, sessile or stiped, branched and even coraloid, white initially, and finally light brown, 3-5 mm long and 350-600 µm in diameter. Smooth surface, with extramatrical hyphae between the dichotomies, forming mycelial strands.

Anatomical characteristics in section: mantle of 40-75 µm wide, of prosenchymatous structure (CHILVERS, 1968). Hyphae 2-2.5 µm in diameter. Smooth mantle surface. Hartig's net developed between the first layers of cortical cells (in some cases reaching the endodermis).

Suillus and *Rhizopogon* are two cosmopolitan ectomycorrhizal genera with a wide range of hosts, principally among the conifers. Many members of both genera have been isolate in pure culture and used in the synthesis of mycorrhizae (GRAND, 1968; LAMB & RICHARDS, 1970; MEJSTRIK & KRAUSE, 1973; PACHLEWSKI & PACHLEWSKA, 1974; MARX, 1969, 1979; MOLINA, 1979; CHU-CHOU & GRACE, 1984; CHU-CHOU, 1985; ACSAI & LARGENT, 1983; PALM & STEWART, 1984; RIFFLE & TINUS, 1985, among others).

R. roseolus has been described in association with different conifers, but never with *Pinus halepensis* . However, *S. collinitus* was noted in association with *P. halepensis* (CHEVALIER & DETOLLE, 1984), although inoculation was peformed with mycorrhizal roots from pines under which *S. collinitus* had fructified in previous years.

Anatomical and morphological characteristics of ectomycorrhizae synthesized between *Suillus collinitus, Rhizopogon roseolus* with *Pinus halepensis* seedlings are described. It is proved experimentally that these fungi are indeed ectomycorrhizal with Aleppo pine.

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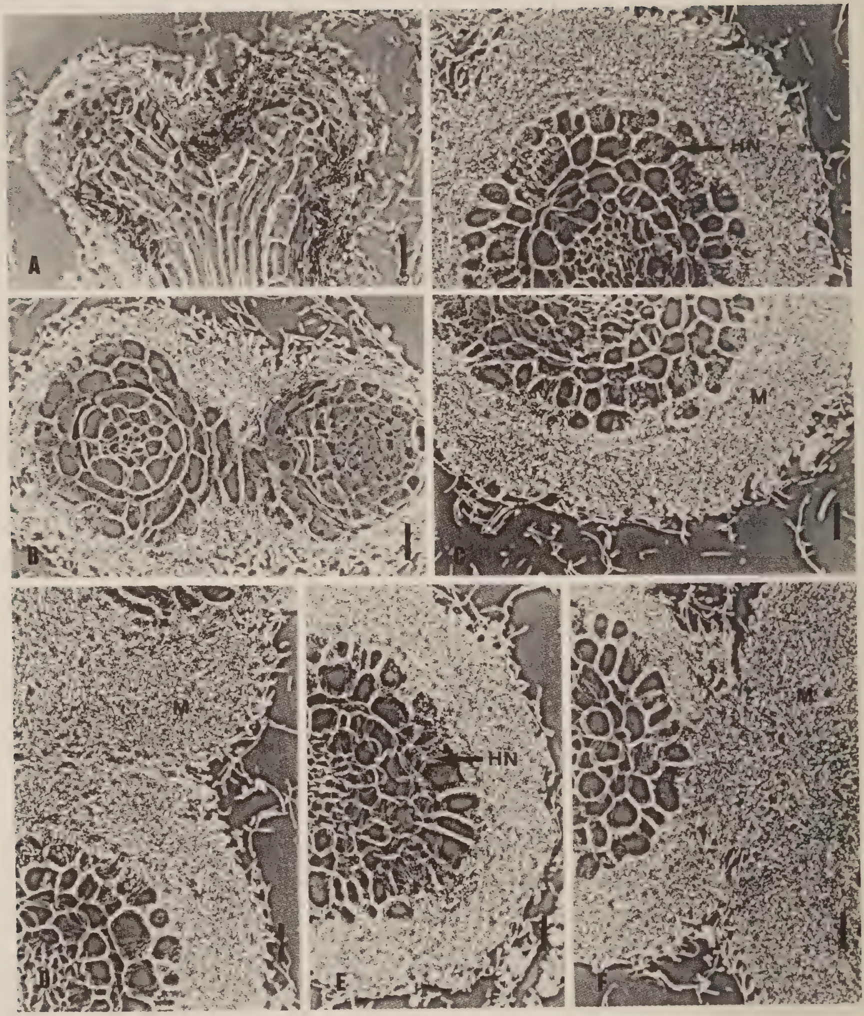

Fig.1.- Laboratory-synthesized ectomycorrhizae of *Suillus collinitus* + *Pinus halepensis*. Bar= 30 µm.

A.- Longitudinal section of bifurcate ectomycorrhiza and tightly appressed mantle.

B.- Cross section of bifurcate ectomycorrhiza.

C,D,E, and F.- Cross sections of mature ectomycorrhizae. Note the thick mantle (M) and development of Hartig net (HN).

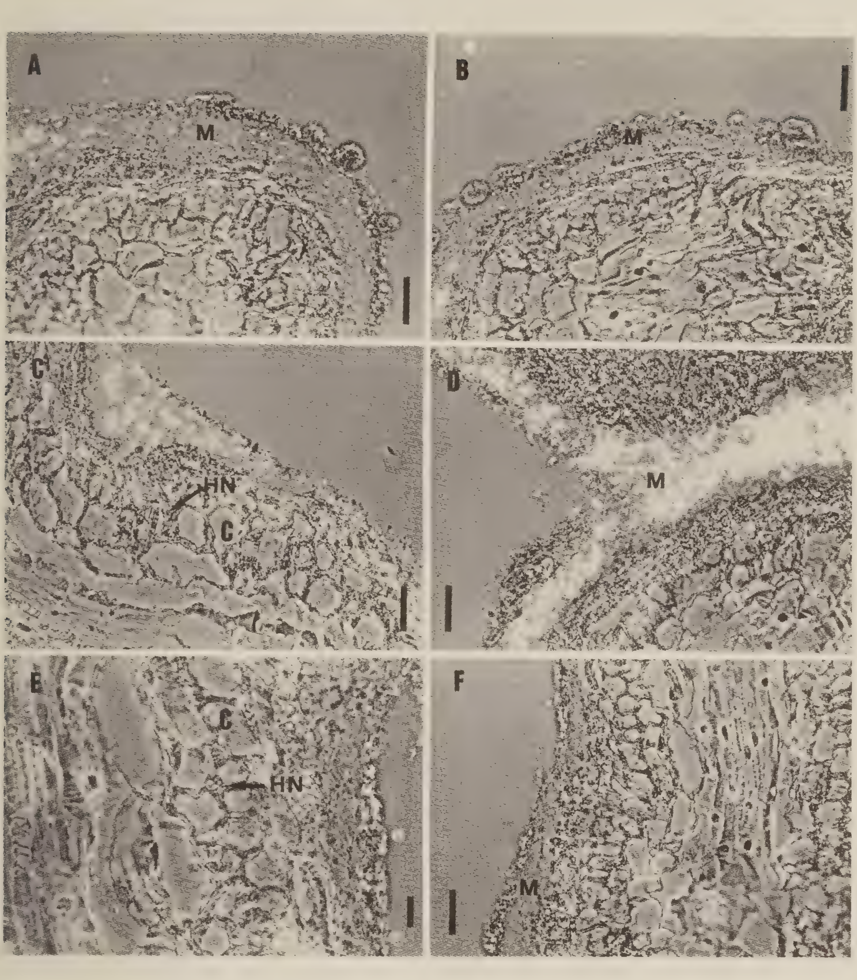

Fig.2.- Laboratory-synthesized ectomycorrhizae of *Rhizopogon roseolus* + *Pinus halepensis*.

A-F.- Cross sections of mature ectomycorrhizae. Note development of Hartig net (HN) and deformation of cortical cells (C). Bar= 35 µm.

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HELICOGOOSIA, A NEW GENUS OF LIGNICOLOUS HYPHOMYCETES

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ABSTRACT

A new genus and species of helicosporous hyphomycetes - **Helicogoosia paradoxa** - occurring on dead bark of **Pinus sylvestris** in south-west of Bohemia, Czechoslovakia, is described and illustrated. From all known helicosporous genera the fungus is well distinguished by different conidiogenous cells and conidia. Conidiogenous cells are lanceolate and very easily detachable leaving pores in the wall in places of their secession. Conidiogenous cells develop by enteroblastic-tretic manner, while conidia develop holoblastically. Conidia are brown, septate, mostly tightly coiled in excentric direction having the apical end outside and the basal end inside the helicoid body.

TAXONOMIC PART

Helicogoosia Hol.-Jech. **gen. nov.**

Deuteromycotina, Hyphomycetes.

Coloniae laxe gossypinae vel tomentosae, brunneae, effusae. Mycelium superficiale ex hyphis repentibus, pallide brunneis, laevibus et ex hyphis aeriis non ramosis, brunneis, rectis vel leviter flexuosis, septatis, crassitunicatis, laevibus, anastomosantibusque compositum. Conidiophora semimacronemata, mononemata, non ramosa vel plus minusve ramosa, determinata vel proliferata, mediobrunnea vel brunnea, aseptata vel septata, crassitunicata, laevia. Cellulae conidiogenae monoblasticae, in conidiophoris incorporatae et terminales vel laterales, determinatae vel aliquando proliferantes, lanceolatae, pallide brunneae usque brunneae, fere crassitunicatae et laeves, saepe facile secedentes; post secretionem pori pellucidi in pariete patefacti. Conidia holoblastica, acrogena, solitaria, sicca, simplicia, circinata, in cursum excentricum helicoidea, septata, non constricta, brunnea, fere

crassitunicata, laevia; cellula apicalis obtusa in peripheria locata et cellula basalis in centro corporis conidii locata; conidia facile cadentia.

Species typica: **Helicogoosia paradoxa** Hol.-Jech.

Colonies loosely cottony or tomentose, brown, effuse. Mycelium superficial, composed of repent, pale brown, smooth hyphae and of aerial unbranched, erect or ascending, straight or slightly flexuous, brown, septate, thick-walled, smooth, occasionally anastomosing hyphae.

Conidiophores arising laterally and singly on the hyphae, semimacronematous, mononematous, unbranched or sometimes loosely branched, straight, determinate or occasionally proliferating, pale brown to brown, aseptate or septate, thick-walled, smooth. Conidiogenous cells monoblastic, integrated, terminal or lateral, determinate or proliferating, lanceolate, pale brown to brown, moderately thick-walled and smooth, becoming easily detached; after secession leaving clear minute pores in the lateral walls of hyphae or conidiophores.

Conidia holoblastic, acrogenous, solitary, dry, simple, circinate, tightly coiled in excentric direction, septate, not constricted, brown, moderately thick-walled, smooth, with an obtuse apical end at the periphery and conical basal end at the center of the conidium body; easily schizolitically seceding.

Etymology: The new genus is named in honour of Prof. Dr. Roger D. Goos, Department of Botany, University of Rhode Island, U.S.A., a student of the helicosporous hyphomycetes.

Helicogoosia paradoxa Hol.-Jech., **spec. nov.**

Coloniae laxe gossypinae vel tomentosae, 2 - 5 mm diam. Hyphae aeriae rectae vel leviter flexuosae, non ramosae, brunneae, saepe ultra 2500 µm longae, 1.8 - 2.8 µm latae, crassitunicatae, laeves, interdum anastomosantes. Conidiophora ut rami laterales enteroblastice in hyphis evoluta, non ramosa vel plus minusve ramosa, aseptata usque 1-3 septata, 8 - 35 µm longa. Cellulae conidiogenae incorporatae, terminales et laterales, lanceolatae, ad basem et apicem angustatae, pallide brunneae usque brunneae, 8 - 20 µm longae, 1.8 - 2 µm latae, saepe facile secedentes, pori pellucidi distincti in pariete patefacti. Conidia circinata, arcte in cursum excentricum 1 1/2 usque 2 1/4 helicoidea, 5-12 septata, non constricta, pallide brunnea usque brunnea, fere crassitunicata, laevia, 3.5 - 5 µm lata, cum cellulis apicalibus obtusis in peripheria locatis et cellulis basalibus conicis in centro corporis conidii locatis; conidia helicoidea 13 - 18 µm in diam.; cellula basalis cum cicatrice

truncata, pallida, 1 μm lata.

Habitat in cortice emortuo deiecto **Pini sylvestris.**

Holotypus: Czechoslovakia: Bohemia merid.-occid.,
distr. Domažlice, in silva inter pagos
Poběžovice et Drahotín, sept.-occid. ab
oppido Domažlice, 26. VII. 1990,
coll. V. Holubová-Jechová (PRM 842854).

Colonies loosely cottony to tomentose, brown, up to 2 - 5 mm in diam.

Aerial hyphae straight or slightly flexuous, unbranched, brown, often more than 2500 μm long, 1.8 - 2.8 μm wide, thick-walled, smooth, occasionally anastomosing.

Conidiophores developing enteroblastically, laterally on the hyphae, unbranched or loosely branched, aseptate to 1-3 septate, 8 - 35 μm long. Conidiogenous cells integrated, terminal or lateral, developing enteroblastically, lanceolate, narrowing both to the apex and to the base, pale brown to brown, 8 - 20 μm long, 1.8 - 2 μm wide, very easily detachable, leaving a distinct clear minute pores in the walls of hyphae, conidiophores or conidiogenous cells. A small pore on the base of the conidiogenous cell is distinct after secession.

Conidia circinate, tightly coiled 1 1/2 to 2 1/4 times, with excentric coiling, 5-12 septate, not constricted at the septa, pale brown to brown, moderately thick-walled, smooth, 3.5 - 5 μm wide, with the apical obtuse cell at the periphery and the basal conical cell at the center of each helicoid conidium, 13 - 18 μm in diam.; the basal cell with a truncate, pale to hyaline, 1 μm wide scar.

Habitat: on dead bark of **Pinus sylvestris** lying on the ground.

DISCUSSION

Helicosporous fungi were reviewed in detail by Goos (1987). Forty- three genera with helicoid conidia are now known. The important characters of the new described taxon above are not, however, found in any of known helicosporous genera.

Interesting and important features of the new taxon are the development of the conidiophores and the conidiogenous cells laterally on unbranched aerial hyphae in an enteroblastic-tretic manner. The conidiogenous cells are solitary and can also proliferate percurrently. Occasional branching of the conidiophores occurs by the lateral development of new conidiogenous cells on short conidiophores and primary conidiogenous cells, again in the enteroblastic-tretic manner.

The conidiogenous cells are lanceolate and narrow, becoming distinctly narrower on the apex and also on the basal end. They are easily detached from the conidiophore, leaving only minute, clear pores in the lateral walls of the hyphae, conidiophores and conidiogenous cells, and leaving no wall remnants on the conidiophore or the conidium.A small pore becomes distictly visible on the base of each conidiogenous cell after secession.

A very similar mode of conidiogenous cell development can be seen in **Edmundmasonia** Subram., and was described in **E. villosa** Hol.-Jech. (Holubová-Jechová 1983). Small, clear pores in the wall of the conidiogenous cells after seccesion can be seen in Matsushima´s figures of **Edmundmasonia pulchra** Subram. (Matsushima 1975). However,they cannot be observed in the walls of the conidiophores of the apparently morphologically similar **Brachysporiella gayana** Batista. This feature leads me to consider **Brachysporiella** Batista and **Edmundmasonia** Subram. as distinct taxa, although other authors do not agree. The conidia of **Edmundmasonia** species are obovoid to pyriform, however, never helicoid.

The conidia of **Helicogoosia paradoxa** resemble those of some species of **Helicoma** Corda, having relatively thick conidial filaments in proportion to their length, and in being non-hygroscopic. Conidia of the new taxon are tightly coiled, circinate to planate, very rarely slightly cochleate (terminology of Goos, 1987). The mode of coiling in the new taxon is distinctly excentric. The base of the conidium is found with the apex of the conidiogenous cell in the centre of the helix, and the apex of the conidium is always found at the periphery. This is in contrast to **Helicoma** and other genera, as **Helicosporium** Nees, **Drepanoconis** Schroet. et Henn., etc. This form of coiling is found only in a few genera - as **Cirrenalia** Meyers et Moore, **Zalerion** Moore et Meyers, **Slimacomyces** Minter (Sutton 1973, Goos 1987). All known genera with excentric coiling, however do not produce tightly coiled conidia; their conidia are often only partly coiled or irregularly coiled in several planes and are mostly constricted at the septa. The characters of colonies and conidiophores in **Cirrenalia, Slimacomyces** and **Zalerion** are also fully different from those occurring in the newly described genus.

Three other species of lignicolous hyphomycetes occur together with **Helicogoosia paradoxa** on the collected sample of **Pinus sylvestris** bark: **Septonema fasciculare** (Corda) Hughes and **Hormiactella fusca** (Preuss) Sacc., both very common microscopic fungi on **Pinus** bark, and **Sporidesmium doliiforme** Minter et Hol.-Jech. The latter fungus is very rare; it was first collected in 1979 on cones of **Pinus mugo** in the Šumava Mts. in south of Bohemia and was found also in Scotland and Finland.

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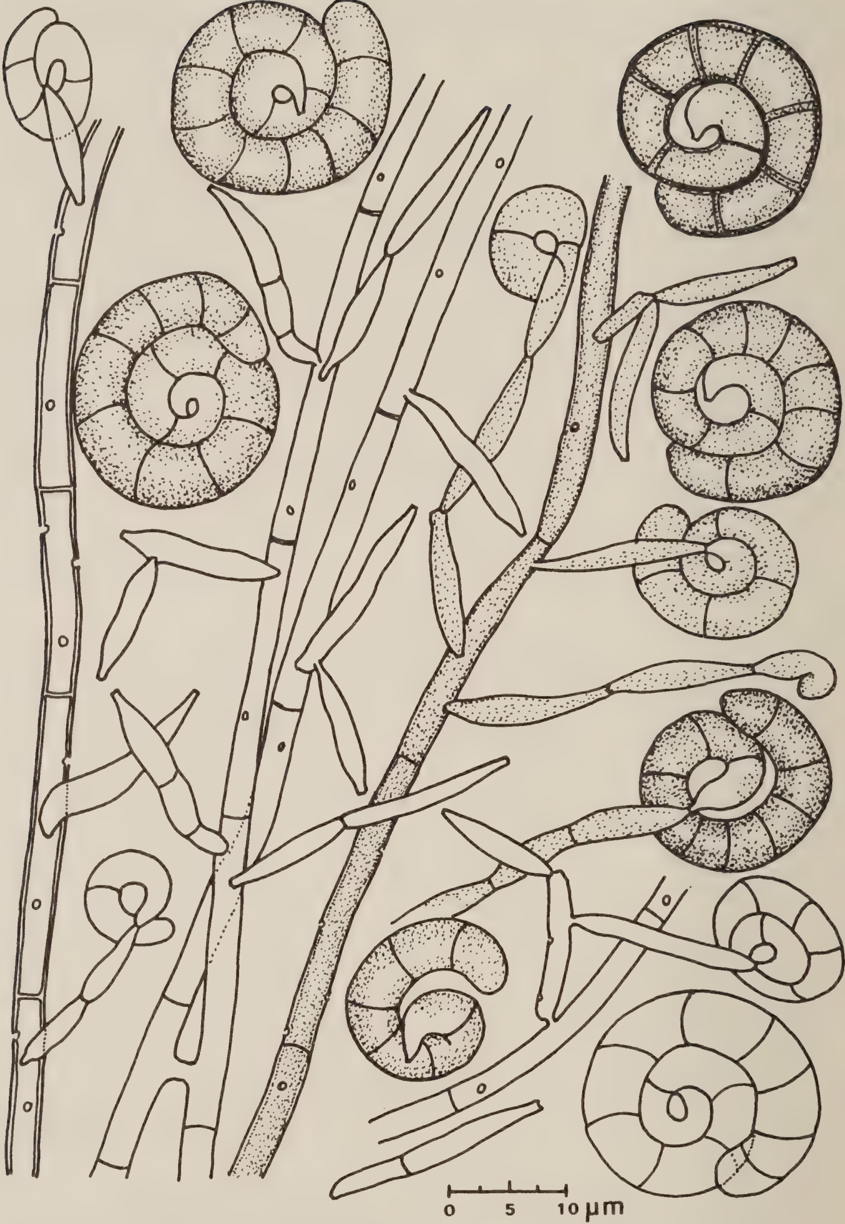

Fig. 1. **Helicogoosia paradoxa** Hol.-Jech.: unbranched aerial hyphae with clear minute pores in the walls and with lateral short conidiophores and conidiogenous cells; helicoid conidia in different stages of their development.

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SCANNINIG ELECTRON MICROSCOPY OF CONIDIOPHORE DEVELOPMENT AND CONIDIOGENESIS IN *CHAETOPSINA FULVA*

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Abstract

Conidiophore morphology and development, and conidiogenesis in *Chaetopsina fulva* were investigated with S.E.M.; generic limits and conidial arrangement after their production are discussed. Enteroblastic (phialidic) conidiogenesis is confirmed.

Specimens (on dead needles of *Cedrus* spp.) of *Chaetopsina fulva* Rambelli, the type species of the genus, recently collected near Rome, have provided the opportunity for further studies of the morphology, conidiophore development and for confirming the conidiogenesis of this species, utilizing the S.E.M..

Methods and Materials

Specimens from pure cultures on soil extract agar and from needles of *C. atlantica,* were fixed in 5% glutaraldehyde in 0.2 M sodium phosphate buffer (pH 7.2) and post-fixed in 1% OsO_4 in 0.2 M cacodylate buffer (pH 7.2); dehydrated in a graded acetone series, critical point dried, coated with gold and then observed with a Cambridge Stereoscan 200.

Specimens examined: - strain N. 1, *C. fulva* Rambelli, pure culture from needles of *Cedrus* sp., leg. M. Leone, III.1987, c/o C.S.A.F., Casalotti, Rome, Italy; specimen N. 2, *C. fulva* Rambelli, on needles of *Cedrus atlantica* (Endl.) Carrière, leg. M. Leone, 3.IX.1987, c/o C.S.A.F., Casalotti, Rome, Italy; strain N. 2, pure culture from the specimen N. 2.

Strain N. 1 was analyzed only in pure culture, because of the impossibility to obtain a good S.E.M. preparation from the original material, which had been dried for herbarium conservation.

Results

a) Development

A seta (fig. 1, a) originates from the submerged (fig. 1, b) or superficial (fig. 1, c) mycelium. During development the apex of the seta is rounded and becomes sharp at maturity. When the seta is close to its maximum length, it produces one, or sometimes more, lateral branches, adherent to it (fig. 1, d), envelopping it and producing secondary, tertiary (or more) branches (fig. 1, e). Conidiogenous cells arise from this repeatedly branched apparatus (figs. 1, f, g). Later, conidiogenous cells begin producing conidia (fig. 2, a).

b) Morphology

S.E.M. observation shows a verrucose surface of mature conidiophore stipes (fig. 2, b) and markedly of the conidiogenous cells (fig. 2, c). The conidia and the neck of the conidiogenous cells are finely echinulate in strain N.1 (fig. 3, b) and smooth in specimen and strain N.2 (fig. 2, f); the two strains are identical in all other features.

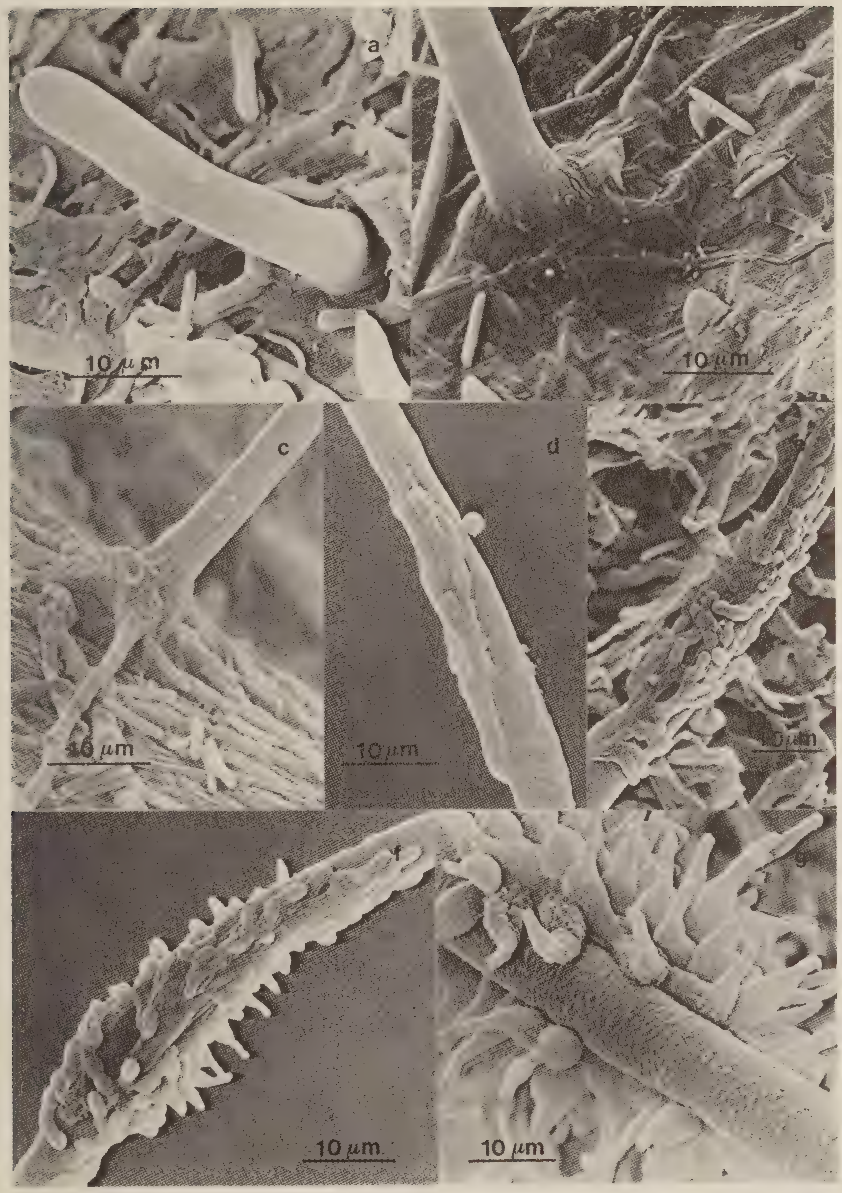
c) Conidiogenesis

The conidia are produced from the interior of the conidiogenous cell (fig. 2, d). After the conidia have seceded, the slightly flaring collarette remains open (fig. 2, e), confirming the phialidic nature of the conidiogenous cell.

Each conidiogenous cell produces numerous conidia, which tend to remain in a parallel package, near the point of production (fig. 2, g). The collarette presents a slightly asymmetric shape (fig. 3, a) and the conidia are asymmetrically tapered at the proximal end (fig. 3, b).

Discussion

The morphology of the setiform conidiophore has been clearly described by Rambelli (1956); moreover he described "conidiis .... ex conidiogenis phialiformibus hyalinis exilientibus": in fact conidiogenesis is surely enteroblastic (phialidic), conidia being produced from the interior of the conidiogenous cell. Kirk & Sutton (1985) applied the terminology of conidiogenesis proposed by Minter *et al.* (1983) to *Chaetopsina* : "*Conidial ontogeny* holoblastic by apical wall building. *Conidial maturation* synchronous with conidial ontogeny. *Conidial secession* schizolytic. *Proliferation* of two types: (1) enteroblastic without progression, leading to periclinal thickening; (2) holoblastic and


a
b
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10 µm
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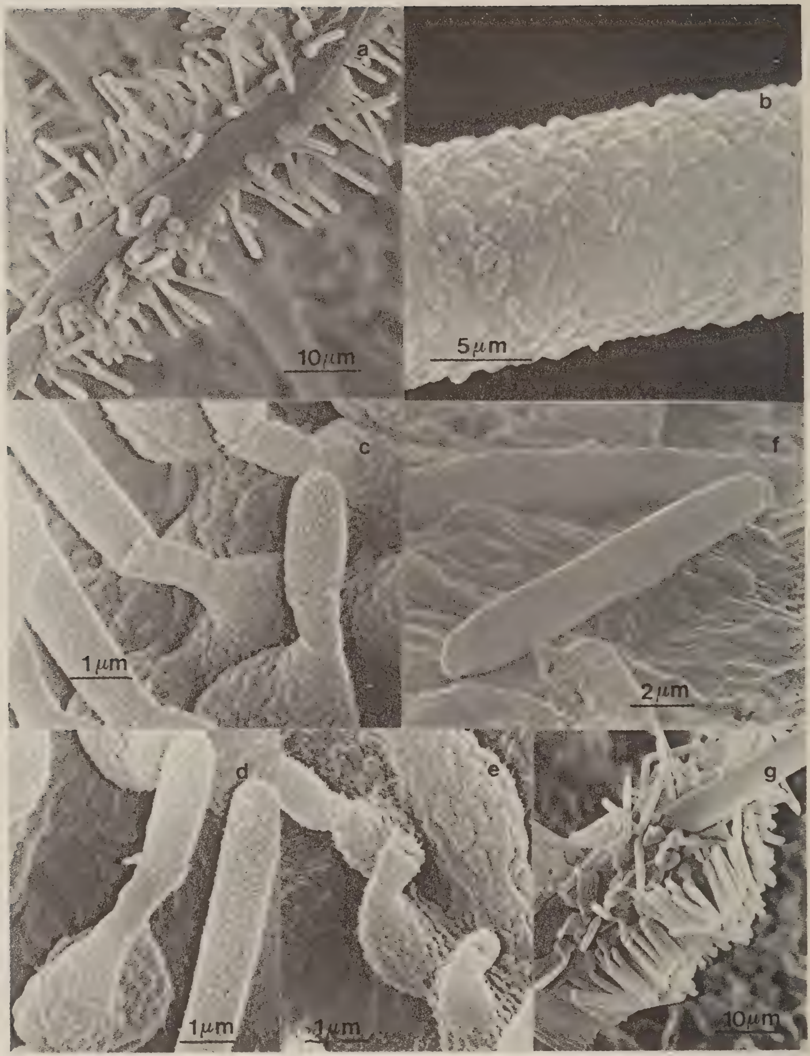
Fig. 1 - *Chaetopsina fulva* : a) initial development of the setiform conidiophore; b, c) submerged and superficial colonization; d, e, f, g) different developmental stages of lateral branches and conidiogenous cells.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g
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Fig. 2 - *Chaetopsina fulva* : a) conidiogenous apparatus in early stage of conidial production; b) upper part of the stipe markedly verrucose; c, d, e) conidiogenous cells producing conidia from the interior; f) smooth conidia typical of the specimen N. 2; g) parallel package of conidia.

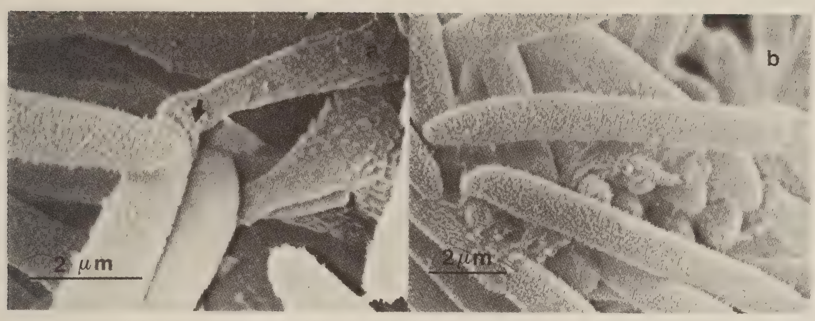

Fig. 3 - *Chaetopsina fulva* : a) asymmetrically shaped neck of a conidiogenous cell; b) finely echinulate conidia (strain N. 1) showing the asymmetrically tapered proximal end.

irregularly sympodial leading to multiple conidiogenous loci". Accepting the method of Minter *et al.* (1983), the above is substantially correct, but the description of two types of proliferation is rather perplexing. In fact, while the first type concerns proliferation within a single conidial locus, which produces numerous conidia through the apposition of new wall layers, without elongation of the conidiogenous cell, the second type concerns conidiogenous cell proliferation, leading to the production of new conidiogenous loci, each proliferating through the apposition of new wall layers. The contemporary presence of these two types of proliferation is commonly accepted for *Dictyochaeta* Speg. (=*Codinaea* Maire).

Accepting the possibility of the presence of a sympodial proliferation in *Chaetopsina*, the distinction between this genus and *Chaetopsis* Greville could also become very slight, based only on the presence of aseptate or 1-septate conidia and this, exactly as suggested by Rambelli (1987), is a specific and not generic characteristic. The discriminant is probably collocated in the distinction (Minter *et al.*, 1982) between proliferation *(Codinaea* and *Chaetopsis)* and regeneration *(Chaetopsina).* Proliferation is a mechanism evolved by numerous fungal species in order to improve the conidiogenous cell efficiency. This mechanism is typical of the species and is normal for all its conidiogenous cells. Regeneration is a mechanism occasionally utilized to overcome damage or other impediments to the function of the conidiogenous cell. In fact, the occasional presence of "polyphialidic" structure is more easly evident in old cultures of *Chaetopsina* spp., where regeneration phenomena are more common.

The occasional presence of polyphialidic structures may be considered a result of a regeneration process, whereas *C. polyblastia* Samuels appears to be more of a case of polyblastic proliferation (Samuels, 1985). At present we do not have sufficient data to verify this, but, if we did, *C. polyblastia*, exactly as suggested by Rambelli (1987), would have had a different collocation. Using cluster analysis, Arambarri and Cabello (1989) showed that *C. polyblastia* is closer to *Chaetopsis grisea* (Ehrenberg) Saccardo than to other species of *Chaetopsina* and *Kionochaeta* Kirk & Sutton.

The surfaces of the conidia are finely echinulate in strain N. 1 and smooth in specimen and strain N. 2. Considering that the conidia in latter case are smooth both on natural substratum and in pure culture, this morphological characteristic could be considered as the unique difference between the two strains, that are identical even in their dimentions.

All species of *Chaetopsina* are characterized by a parallel aggregation of the conidia. This feature has an adaptative value. The presence of packed conidia is in fact common in such genera as *Codinaea* and *Circinotrichum* Nees which are characterized by thin walled scolecospores. In these genera the conidia are probably stored and initially dispersed as packets. They are more resistant to low humidity, while in the presence of water the mucilage is dissolved and the conidia are separately dispersed. All the species of these genera present conidia with an asymmetrically rounded proximal end. This characteristic, together with the shape of the collarettes and a delicate equilibrium between the cohesion and lubrification due to the presence of mucilage, determine the characteristic conidial arrangement: each conidium, pushed by the following one, runs on the collarette with the curved proximal end and remains attached to it, while the following conidium runs at its side. When the collarette is large and regularly shaped, as in *Codinaea*, the conidia form conspicuous slimy masses on the conidiogenous locus and around the main axis of the conidiogenous cell. When the collarette is slightly asymmetric, as in *Chaetopsina fulva*, the parallel conidia are moved laterally to the main axis of the conidiogenous cell. Considering the prominence and the probable adaptative value of this feature, the latter can be regarded as a characteristic peculiar to *Chaetopsina*. From this viewpoint, inclusion of species with catenulate conidia ought to be avoided (Rambelli, 1987). *C. catenulata* Samuels has been described as possessing phialides with periclinal wall thickening (Samuels, 1985); and this agrees with the observations concerning the type species of the genus. However, the presence of flat protuberant scars at each end of the catenulate conidia could be due to a different type of conidiogenesis.

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NOTES ON HYPHOMYCETES. LXII. CONCERNING CHLORIDIUM VIRESCENS VAR. ALLANTOSPORUM, A NEW TAXON, C. VIRESCENS VAR. CAUDIGERUM, AND CHLORIDIUM PHAEOSPORUM, FROM SOUTHERN AFRICA

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ABSTRACT

A new variety of *Chloridium virescens* (Pers.) W. Gams & Hol.-Jech., var. *allantosporum*, is described and illustrated from a collection on dead wood made in the Transvaal, South Africa. Var. *allantosporum* differs from the three presently recognized varieties of this species (vars. *virescens*, *caudigerum* (Höhn.) W. Gams & Hol.-Jech., and *chlamydosporum* (van Beyma) W. Gams & Hol.-Jech.), as the name indicates, by possession of allantoid conidia. Collections of *C. virescens* var. *caudigerum* and *Chloridium phaeosporum* W. Gams & Hol.-Jech., known previously only from its type material on decaying wood in West Virginia, U.S.A., are reported from southern Africa and the fungi are redescribed and illustrated.

INTRODUCTION

In their monographic study of the genus *Chloridium* Link, Gams and Holubová-Jechová (1976) treated three previously recognized taxa [see Hughes (1958), Ellis (1971)], namely *C. viride* Link, *C. caudigerum* (Höhn.) Hughes, and *C. chlamydosporis* (van Beyma) Hughes, as a single species. They adopted the binomial *C. virescens* [basionym *Dematium virescens* Pers.] for the type species, *C. viride*, and the latter name was listed as a synonym. The name *D. virescens*, applied to the same fungus, predates *C. viride* by some years [see Persoon (1797), Link (1809)]. Although a specimen [910.25-753] labeled '*Dematium virescens* Pers.' in Herb. Persoon (L) was found, when examined by Gams and Holubova-Jechova (1976), not to bear *C. virescens*, but rather the *Helicosporium* anamorph of *Tubeufia cerea* (Berk. & Curt.) Booth [*Helicosporium vegetum* Nees], the authors concluded, on the basis of Persoon's

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description, that *D. virescens* was the same as that named *C. virens* by Link (1809). They expressed the opinion that this specimen could not be the holotype of *D. virescens* and that Persoon's original material has probably been lost. Furthermore, they thought it probable that Persoon had mistaken the *H. vegetum* specimen for his *D. virescens* as a result of only macroscopic examination. Sivanesan (1984) took up the binomial *Dematium virescens* Pers. for the anamorph of *Tubeufia cera* and transferred it into *Helicosporium* Nees as *Helicosporium virescens* (Pers.) Sivanesan. Since *D. virescens* predates *H. vegetum*, the binomial applied by Nees (1817) to the type species of his genus, *H. virescens* took priority over it. Goos (1989) followed Sivanesan (loc. cit.) in adopting the name *Helicosporium virescens* but was unaware (R. D. Goos, personal communication) that *Chloridium virescens* (Pers.) W. Gams & Hol.-Jech. was based upon the same basionym. No mention of this was made by Sivanesan (loc. cit.) either. Since Persoon's generic diagnosis of *Dematium virescens* reads "sporulis globosis aut ovalibus" it seems highly unlikely that he was describing *Helicosporium vegetum* and therefore it is reasonable to assume that the original specimen to which he applied the name *D. virescens* has been lost. Despite the fact that a specimen of *H. vegetum*, bearing the binomial *D. virescens*, exists in Persoon's herbarium, the use of this name for the *Helicosporium* seems questionable. The reasoning behind the decision of Gams and Holubova-Jechova (1976) to adopt the name *Chloridium virescens* for *C. viride* appears to be sound. The binomial *H. vegetum* should, therefore, be reinstated for the anamorph of *T. cera*. Persoon (1822) considered *D. virescens* and *C. viride*, to be conspecific. The specific epithet '*virescens* Pers.' was also recognized by Fries (1832) as having precedence over '*viride* Link'. Gams and Holubova-Jechova (1976) designated Link's holotype of *C. viride* [Rostock, Herb. Link (B)] as neotype of the species. The differences in the three taxa originally recognized as separate species lie in form and coloration of conidial aggregations at the tip of conidiogenous cells, occurring either as, in the case of *C. chlamyosporis*, heads, or as, in the others, elongated cirrhi. Cirrhi of *C. virescens* and *C. caudigerum* differ in the former, as the name indicates, being yellowish-green, whereas those of the latter are invariably whitish. In addition, these entities are distinguished by the precise shape and size, particularly length/width ratios, of their conidia. Their conidia vary in shape from more or less subglobose in *C. virescens* to ellipsoidal in the others.

Opinions as to the most appropriate classification of the above mentioned taxa have revolved around whether or not the three entities should be recognized as separate species, considered synonymous, or given subspecific taxonomic rank. Mangenot (1952) documented the differences distinguishing *C. caudigerum* [as *Cirrhomyces caudigerus* Höhn.] and *C. chlamydosporis* [as *Bisporomyces chlamydosporis* van Beyma]. These include mycelium pigmentation, chlamydospore characteristics, particularly whether solitary or in chains, as well as size and arrangement of conidia. Hughes (1958) accepted the distinctiveness of these taxa, transferring them into *Chloridium*, thereby making *Cirrhomyces* Höhn., and *Bisporomyces* van Beyma synonyms of that genus. This taxonomy was accepted by Ellis (1971), who used conidial size and arrangement to separate the three species. Tubaki (1963), Barron (1968), and Matsushima (1975) also treated *C. chlamydosporis* as a separate species and likewise *C. caudigerum* by Sivasithamparam (1975). Meyer (1959), however, considered *C. caudigerus*, *B. chlamydosporis* and *Sphaeromycetella leucocephala* Arnaud [now accepted as a synonym of *C. virescens* var. *caudigerum* (see Gams and Holubová-Jechová, 1976, and below)] to be synonymous. Gams and Holubová-Jechová (1976) reached a compromise between

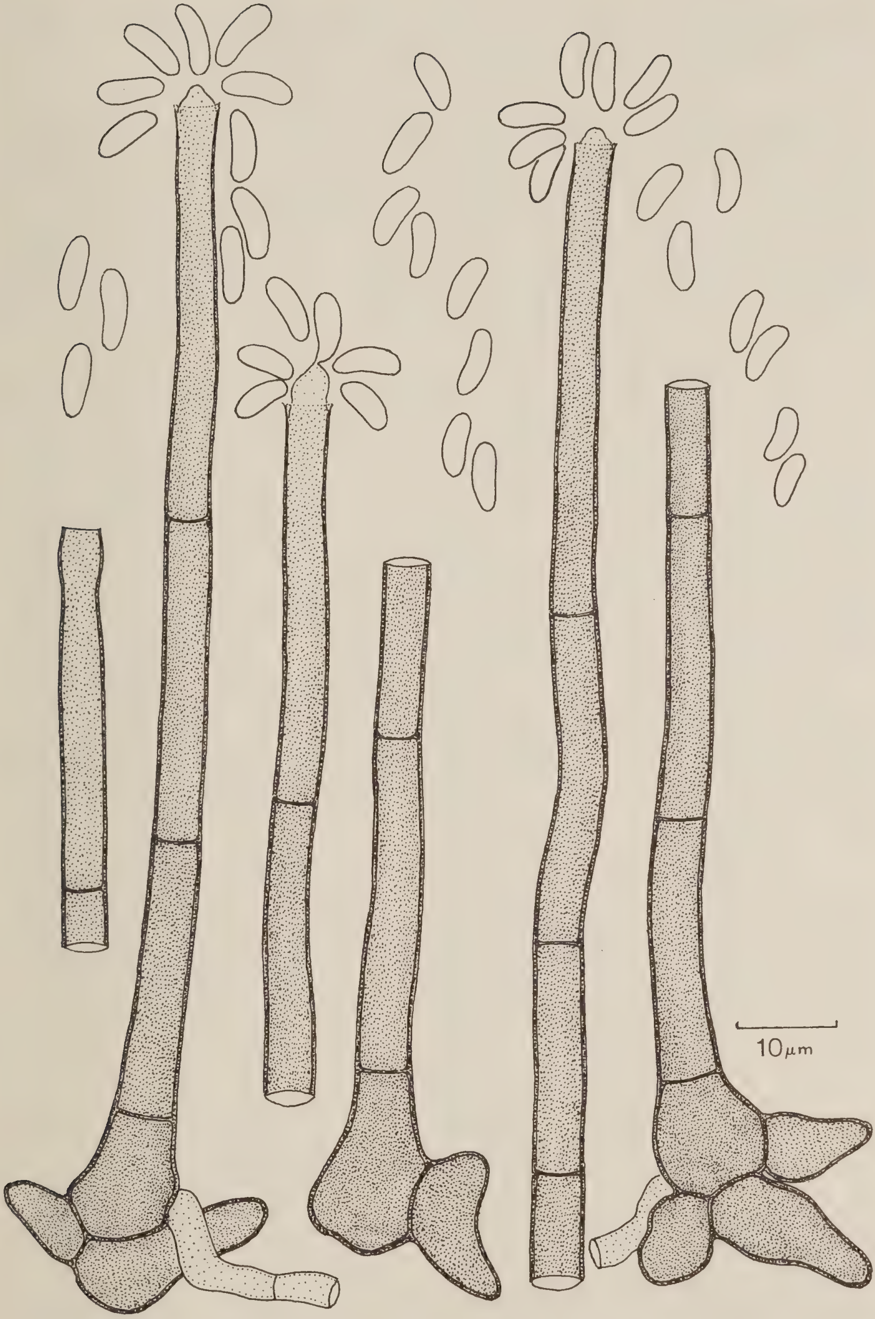

FIGURE 1. *Chloridium virescens* var. *allantosporum*. Conidiophores and conidia.

these positions by recognizing the differences between the taxa at varietal rank. Thus, three varieties were established; namely *C. virescens* var. *virescens* (autonym), var. *caudigerum*, and var. *chlamydosporum.*

Gams and Holubová-Jechová (1976) reported proving *Chaetosphaeria vermicularioides* (Sacc. & Roum.) W. Gams & Holubová-Jechová [≡ *Eriosphaeria vermicularioides* Sacc. & Roum.] to be the teleomorph of *Chloridium virescens* by isolating the fungus *in vitro* from ascospores. Furthermore, cultures from ascospores of three collections identified as *C. vermicularioides*, together with examination of eight additional herbarium specimens, showed that all three varietal forms are associated with the same teleomorph. In spite of consistent differences in the anamorph types, the fact that their connected teleomorphs are indistinguishable provides a compelling reason for classifying them as varieties of a single species.

During the course of collecting saprophytic, dematiaceous hyphomycetes on dead leaves and decorticated wood in southern Africa (Sinclair, 1990; Sinclair *et al.*, 1990), a number of *Chloridium* species have been encountered. These include *C. matsushimae* W. Gams & Hol.-Jech., and two novel species, *C. smithii* Sinclair & Eicker and *C. transvaalense* Morgan-Jones, Sinclair & Eicker (Morgan-Jones *et al.*, 1983; Sinclair and Eicker, 1985). In addition to these, two collections of *C. virescens* have been made. One bears similarity to *C. virescens* var. *chlamydosporum* in possessing conidiophores at whose apex the meristematic conidiogenous tip protrudes a short distance beyond the terminal collarette, and in having narrowly ellipsoid conidia aggregated in heads. It differs from that, and the two other recognized varieties, however, in bearing longer conidia that are slightly curved and allantoid in shape. It differs from var. *chlamydosporum* also in lacking chlamydospores, or at least such structures are not present in the specimen examined , other than a few thick-walled, swollen, mid-brown cells proximal to the base of the conidiophores. Because of these differences, this collection, made in the Transvaal, is named and described herein as a fourth variety of *C. virescens.* The other collection, made in the Transkei, has been identified as C. virescens var. *caudigerum*, and is also described.

Chloridium phaeosporum W. Gams & Hol.-Jech., was described from a single collection made on rotten wood in Morgantown, West Virginia, and originally tentatively identified by its collector, H.L. Barnett, as '*Haplochalara* ?' (Gams and Holubova-Jechova, 1976). A second collection of this species, with conidiophores that are better developed, has been made in South Africa, and has provided an opportunity to give further account and illustration of it. A comparison with the type material has been made.

TAXONOMIC PART

Chloridium virescens var. *allantosporum* var. nov. (Figure 1).

A varietate typica conidiis allantoideis, 4 - 6 X 1.8 - 3.3 μm differt.

In ligno decorticato, Mariepskop, N.E. Transvaal, South Africa, September 1984, R.C. Sinclair, AUA, holotypus.

Colonies effuse, brownish black, rather sparse, thinly hairy. Mycelium mostly immersed in the substratum, composed of branched, septate, smooth,

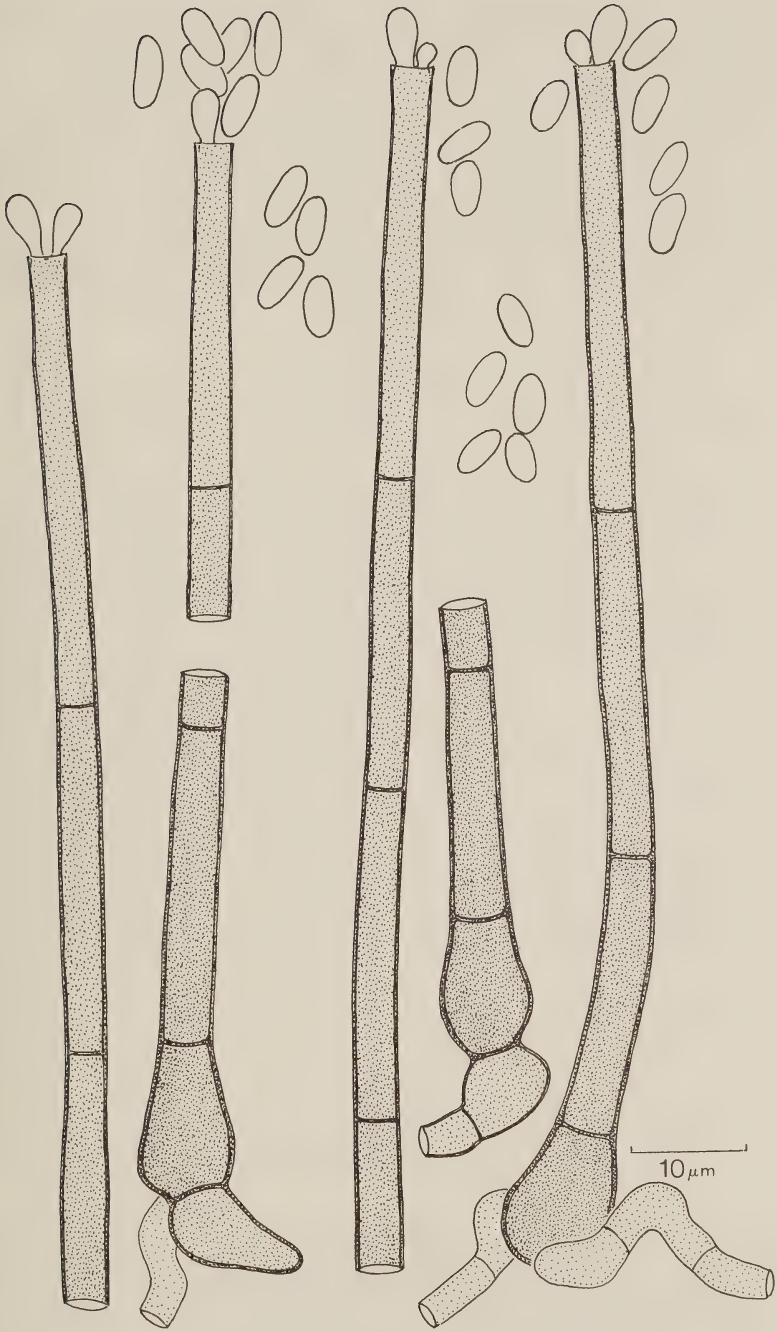

FIGURE 2. *Chloridium virescens* var. *caudigerum*. Conidiophores and conidia.

subhyaline to pale brown, 2 - 3 µm wide hyphae. Conidiophores macronematous, mononematous, straight or very slightly flexuous, simple, cylindrical, thick-walled, up to seven-septate, smooth, pale to mid brown, attenuating slightly and somewhat paler toward the apex, determinate or, very rarely, proliferating percurrently, 90 - 150 X 4 µm, wider, up to 5 µm, at the non-flaring apical collarette, often with a bulbous base, up to 8 µm wide. Stubby, thumb-like, swollen cells often projecting from the extreme base. Conidiogenous cells monophialidic, terminal, integrated, with a conical, meristematic extension protruding up to 4 µm beyond the collarette, giving rise to a sequence of conidia holoblastically in the manner of a sympodula. Conidia hyaline, smooth, unicellular, narrowly ellipsoid to mostly allantoid, accumulating in a compact, whitish, slimy mass at the tip of each conidiophore, often bi-guttulate, 4 - 6 X 1.8 - 3.3 µm. Chlamydospores absent.

On decorticated wood; South Africa.

Collection examined: Mariepskop, N.E. Transvaal, South Africa, September 1984, R.C. Sinclair, AUA, PREM 48911, type.

The conidia of *C. virescens var. allantosporum*, when viewed on a microscope slide, appear as a fan-shaped, radiating cluster, surrounding the protruding, fertile conidiogenous cell extension. This protrusion, as indicated above, is akin to that occurring in *C. virsecens* var. *chlamydosporum*, but is even more pronounced than in that taxon. The process of conidium ontogeny that gives rise to this morphology is similar to that in *Blastophorum truncatum* Matsushima, *Cacumisporum capitulatum* (Corda) Hughes, and *Chaetoblastophorum ingramii* Morgan-Jones (see Goos, 1969; Matsushima, 1971; Morgan-Jones, 1977). The conidiophores of var. *allantosporum* are similar in length to those of vars. *caudigerum* and *chlamydosporum*. Those of var. *virescens* tend to be shorter (see Ellis, 1971; Gams and Holubová-Jechová, 1976). In this regard, it should be noted that there are appreciable differences in conidiophore lengths cited in the literature. Gams and Holubová-Jechová gave no conidiophore dimensions for var. *caudigerum* but Höhnel (1903) gave their length as 100 - 160 µm. Mangenot (1952) stated that conidiophores of this variety can be up to 250 µm long *in vitro*. Those of our collection from South Africa (see below) are somewhat shorter. Van Beyma (1940) reported conidiophores of var. *chlamydosporum* to be 60 - 180 µm long, whereas Gams and Holubová-Jechová gave their length as 70 - above 100 µm, before proliferation. Mangenot (1952) stated that they may be as long as 600 µm *in vitro*.

Chloridium virescens var. *caudigerum* (Höhn.) W. Gams & Hol.-Jech., *Stud. Mycol.* 13: 19, 1976 (Figure 2).

≡ *Cirrhomyces caudigerus* Hohn., *Ann. Mycol.* 1: 529, 1903.

= *Sphaeromycetella leucocephala* Arnaud, *Bull. Trimest. Soc. Mycol. Fr.* 69: 274, 1953 [invalidly published because of lack of Latin diagnosis: Article 36 (ICBN)].

Colonies effuse, blackish, sparse, hairy. Mycelium mostly immersed in the substratum, composed of branched, septate, smooth, pale brown, 2 to 3.5 µm wide hyphae. Conidiophores macronematous, mononematous, more or less erect, mostly straight, simple, cylindrical but attenuating very gradually toward the apex, up to seven-septate, smooth, pale to mid brown, paler distally, 60 - 110 X 3

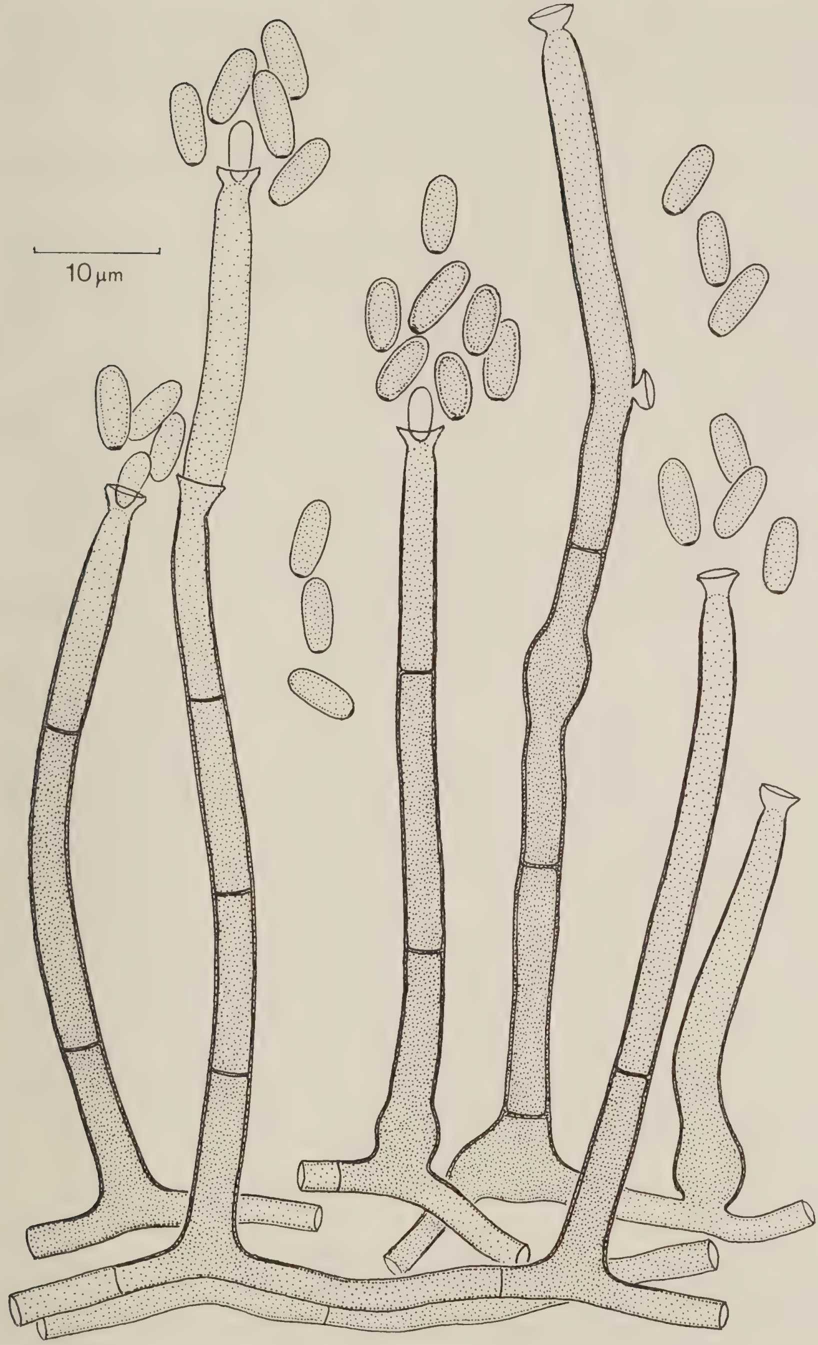

FIGURE 3. *Chloridium phaeosporum*. Conidiophores and conidia.

- 3.5 µm, somewhat bulbous and up to 7 µm wide at the base. Conidiogenous cell monophialidic, terminal, integrated, with a non-flared collarette at the extreme apex; conidiogenous loci below level of collarette. Conidia hyaline, smooth, unicellular, ellipsoidal, accumulating at the apex as a whitish cirrhus, 3 - 5 X 1.5 - 2.5 µm..

Collection examined; on dead wood, Mbotyi, Transkei, southern Africa, December 1982, R.C. Sinclair, AUA.

Varieties *caudigerum* and *chlamydosporum* are very close, differing only in a very slight difference in conidial size and the fact that the former bears conidia in cirrhi rather than heads. Gams and Holubová-Jechová (1976) stated that they are hardly distinguishable in culture. Both form chlamydospores and although in var. *chlamydosporum* these are produced more abundantly, this characteristic seems too variable to be a reliable criterion for differentiating the two. No chlamydospores were observed in the above described collection of var. *caudigerum*. Formation of cirrhi, as opposed to heads, seems also to be variable, dependent upon age and, in nature, possibly growth coniditions. Young conidiophores at first bear conidia in heads, cirrhi only forming following production of many conidia. The collection from the Transkei is assigned to var *caudigerum* advisedly since no well-developed cirrhi could be observed. In it, however, conidia are formed from conidiogenous loci within the collaratte and not from an apical meristematic protrusion as is sometimes the case in var. *chlamydosporum* (see Gams and Holubová-Jechová, 1976). Persiani and Maggi (1990) recently described the same method and details of conidiogenesis in *Gonytrichum macrocladum* (Sacc.) Hughes and adopted the term 'sympodulophialides' coined by Hammill (1972) for conidiogenous cells of *C. virescens* var. *chlamydosporum* [as *C. chlamydosporis*]. When conidia are formed from conidiogenous loci at or just below the level of the collarette, as in varieties *virescens* and *caudigerum*, two conidia usually remain attached (see Figure 2) at the conidiophore tip when a microscope slide preparation is made. In var. *virescens*, the meristematic tip of the conidiogenous cell may sometimes protrude slightly above the collarette (Gams and Holubová-Jechová, 1976; Cole and Sampson, 1979). When van Beyma (1940) erected the genus *Bisporomyces* [based on *C. virescens* var. *chlamydosporum* = *Bisporomyces chlamydosporis* van Beyma], as the name indicates, this characteristic was noted. With regard to position of conidiogenous loci, var. *chlamydosporum* seems variable and there may well, therefore, be a continuum between it and var. *caudigerum*. Hammill (1972) also noted variability in the position of the conidiogenous apex in var. *chlamydosporum*. Whether or not position of the conidiogenous loci in relation to the collarette affects the final arrangement of the conidia is an interesting question. It may well be that when the meristematic, conidiogenous tip extends as a protrusion a short distance above the collarette, as in var. *allantosporum*, the conidia, as they are produced, tend to splay out and accumulate as a head, whereas when they originate slightly below the collaratte a columnar aggregation occurs.

Chloridium phaeosporum W. Gams & Hol.-Jech., *Stud. Mycol.* 13: 27, 1976 (Figure 3).

Colonies effuse, olivaceous brown, often dense, velvety to hairy, frequently in tufts. Mycelium partly immersed in the substratum, partly superficial and forming a loose felt, composed of branched, septate, smooth, pale to mid brown, 2 to 3.5 µm wide hyphae. Superficial hyphae sometimes aggregated in strands of a few, generally thicker-walled and more pigmented than immersed hyphae. Conidiophores macronematous, mononematous, frequently arising more or less perpendicularly from the repent, superficial hyphae, erect, straight or slightly flexuous, simple, cylindrical, septate, smooth, pale to mid brown, progressively paler and attenuating gradually toward the apex, determinate or, occasionally, proliferating percurrently, or, more rarely, sympodially, 26 - 58 X 2 - 3.5 µm, following proliferation up to 74 µm in length. Conidiogenous cells monophalidic or, where sympodial, polyphialidic, terminal, integrated, more or less cylindrical, constricated abruptly immediately below the collarattes. Collarettes cupulate, 1 - 2 µm wide, 1.5 - 2.5 µm deep, with a conidiogenous locus at the base, displaced laterally following sympodial growth and lying sideways on the conidiogenous cell. Conidia very pale olivaceous brown, smooth, unicellular, ellisoidal to oblong, obtuse at the apex, with a dark hilum at the subtruncate base, aggregated in heads, 3 - 6 X 1.5 - 2.5 µm.

Collections examined: on appreciably decayed wood, Morgantown, West Virginia, U.S.A., May 1953, H.L. Barnett, DAOM 40413, holotype; on dead wood, Golden State Highlands National Park, Orange Free State, South Africa, March 14, 1979, R.C. Sinclair, AUA.

Chloridium phaeosporum is unique in the genus in having pigmented conidia. It is classified in section *Gongromeriza* (Preuss) W. Gams & Hol.-Jech. because of possession of pronounced collarettes and percurrently proliferating phialides. The fact that these can also proliferate sympodially is a feature that it shares in common with members of section *Psilobotrys* (Sacc.) W. Gams & Hol.-Jech.

ACKNOWLEDGMENTS

We thank Dr. J. Ginns, Curator, National Mycological Herbarium, Biosystematics Research Centre, Ottawa, Canada, for the opportunity to examine the type of *C. phaeosporum* housed in DAOM. Dr. Roger D. Goos, Department of Botany, University of Rhode Island, Kingston, reviewed the manuscript, for which we are grateful.

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MYCOTAXON

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SCOLICOSPORIUM PAUCISEPTATUM NOM. NOV.

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During the examination of fungi present on *Robinia*, a new species of the monotypic genus *Scolicosporium* Lib. apud Roum., was detected. This species is here described and illustrated.

Scolicosporium pauciseptatum O. Const., nom. nov. – Figs 1, 2.

Synonym: *Hendersonia fusarioiodes* Sacc. – Mycotheca veneta 998. 1876; also in Michelia 1: 213. 1878.

Conidiomata immersed, appearing as brown to dark brown, discoid bodies, c. 200 μm diam, stromatic, base composed of thick–walled, brown cells, 4–10 μm diam, fertile part with paler cells with thinner wall. *Conidiophores* hyaline, simple or rarely branched, septate. *Conidiogenous cells* integrated, terminal, more or less cylindric, hyaline, annellidic, 6–10 x 2–3 μm. *Conidia* falcate, rarely sinuous, smooth–walled, (22–) 30–35 (–50) μm long, 3.5–5 μm wide in the median part, (3–) 5 (–7)– septate, olivaceous, terminal cells paler and with thinner walls, base truncate, 1.5–2 μm broad, apical cell subulate. *Teleomorph* unknown.

Type on decorticated wood of *Robinia pseudoacacia* L., Italy, Conegliano, May 1876, coll. C. Spegazzini (PAD! - lectotype; UPS! - isolectotype).

Additional specimens examined: (all under *Hendersonia fusarioides*, on *Robinia pseudoacacia*): Italy, near Conegliano, Aug. 1877, C. Spegazzini in Thümen, Herb. mycol. oec. 588 (UPS); ditto, summer 1877 in Thümen, Myc. univ. 1076 (PAD, UPS); France, Pyrénées centr., Bagnères-de-Luchon, summer, coll. Ch. Fourcade in Roumeg., Fungi sel. exs. 4751 (UPS).

The available epithet *fusarioides* could not be used in *Scolicosporium* because it is already preoccupied under *S. fusarioides* (Sacc.) B. Sutton, now considered a synonym of *Excipularia fusispora* (Berk. & Broome) Sacc. (Spooner & Kirk 1982).

Although several taxa have been described in *Scolicosporium*, the only accepted species is *S. macrosporium* (Berk.) B. Sutton (Spooner & Kirk 1982). *Scolicosporium pauciseptatum* differs from *S. macrosporium* by its much shorter (average 30–35 vs. over 100 μm) and narrower (3.5–5 vs. over 10 μm) conidia with fewer (av. 5 vs. over 10) septa. In addition, the length/width ratio of most of the median cells in mature conidia is <1 in *S.*

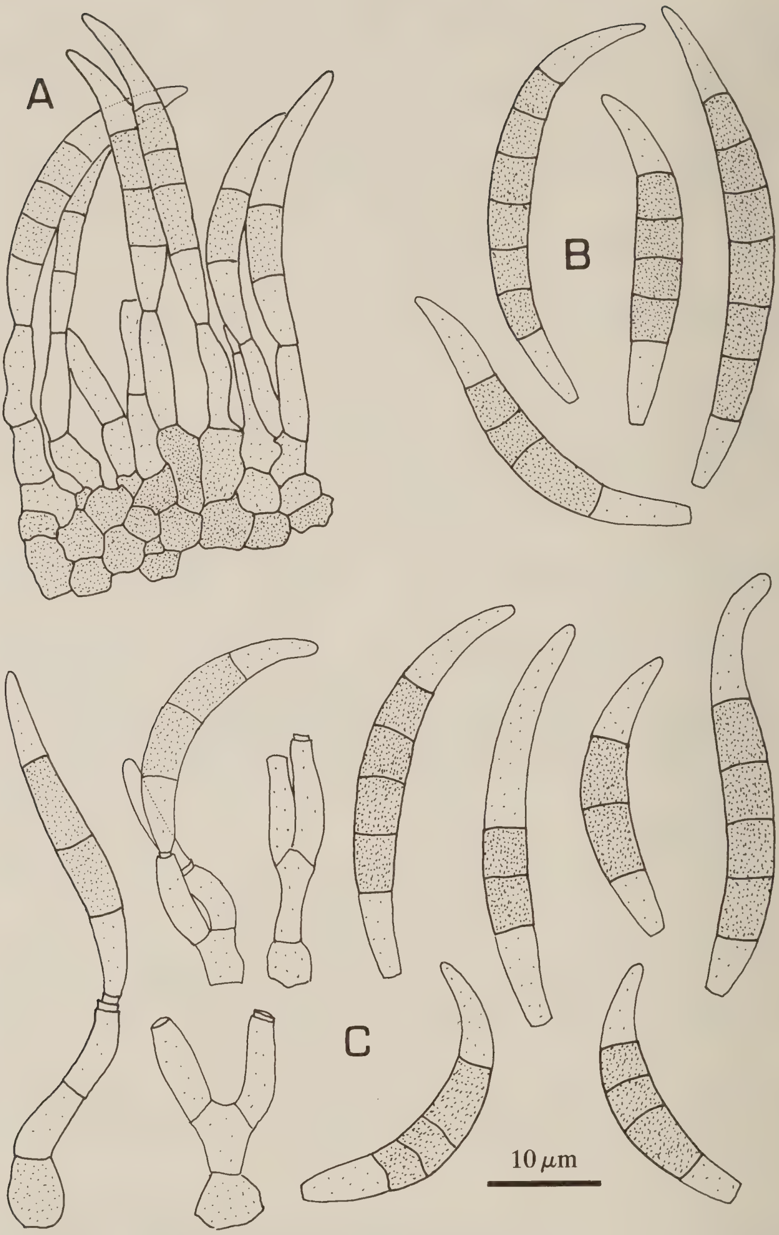

Fig. 1. *Scolicosporium pauciseptatum*. Conidioma, conidiogenous cells and conidia. A. From Sacc., Myc. veneta 998 (UPS). B. From Roumeg., Fungi sel. exs. 4751 (UPS). C. From Thümen, Myc. univ. 1076 (PAD).

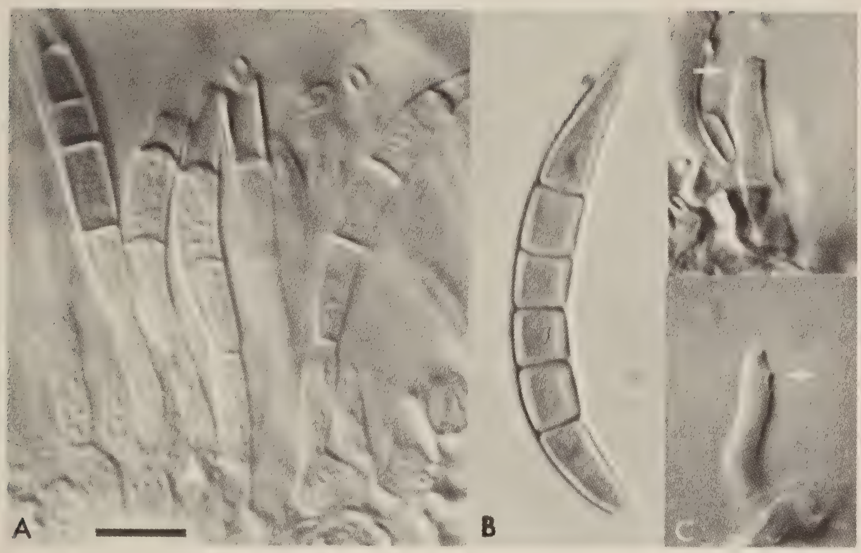

Fig. 2. *Scolicosporium pauciseptatum*. A. Conidioma. B. conidium. C. Conidiogenous cells. Arrows show the annellations. Bar = 10 μm.

macrosporium, but >1 in *S. pauciseptatum*. The annellidic condition of the conidiogenous cells in *S. pauciseptatum* is less visible in immature specimens (Figs 1A, 2A), as is the case with the type, but is obvious in fully developed ones (Figs 1C, 2C).

The genus *Scolicosporium* was placed by Sutton (1977, 1980) within the Coelomycetes although this fungus also shows Hyphomycetes affinity (Spooner & Kirk 1982). The conidioma of *S. pauciseptatum* exhibits the same intermediate pattern. It is embedded into the substratum, a character of a coelomycete, but it has a sporodochium–like structure and is not covered by the host tissue, which places it within hyphomycetous fungi.

Saccardo (1880: 120) suggested that *Hendersonia fusarioides* is the acervular state of *Coryneum fusarioides* Sacc. (now known as *Excipularia fusispora* (Berk. & Broome) Sacc.). This assumption was rejected by Sutton (1975: 110), and the studies by Spooner & Kirk (1982) clearly pointed out the different conidiogenesis patterns of these two fungi. During this study several coelomycetes were found on the pieces of substratum on which *S. pauciseptatum* is present but no connection could be traced between them and *S. pauciseptatum*. As the substratum consist of old, decorticated wood, these fungi are most probably colonizers.

As pointed out by Sutton (1975: 111) *Scolicosporium* is heterogeneous. Almost all described species belong to other genera. The taxonomic status of most species was commented upon or clarified by Sutton (1975), and Spooner & Kirk (1982). However, the following three taxa were left:

Scolicosporium barringtoniae Viennot-Bourgin – Bull. trim. Soc. mycol. Fr. 79: 108. 1963. Described from Madagascar as a leaf parasite of *Barringtonia racemosa*. Having 60–100 μm long, 'helicoidal' conidiophores and cylindric to obclavate, 1–2–septate conidia, this is a *Cercosporidium*–like fungus rather than *Scolicosporium*. Most probably it is conspecific with *Cercosporidium barringtoniae–acutangulae* Kamal, Gupta & Verma (1987) described from India.

Scolicosporium gei Chona, Munjal & Kapoor – Indian Phytopath. 10: 154. 1957. Found in India on leaves of *Geum urbanum*. Its uniseptate conidia exclude this fungus from *Scolicosporium*.

Scolicosporium lactucae Munjal & Kapoor – Indian Phytopath. 16: 91. 1963. A parasite of *Lactuca* sp. in India, described as having uniseptate conidia. This fungus is definitely not related to *Scolicosporium*.

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STUDIES ON THE GENUS PHYLLOPORUS IN MEXICO, I. DISCUSSION OF THE KNOWN SPECIES AND DESCRIPTION OF A NEW SPECIES AND A NEW RECORD

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RESUMEN

Se describe a *Phylloporus guzmanii* Montoya & Bandala como especie nueva, la cual se distingue por la forma y tamaño de las basidiosporas, el color del píleo y el caracter cerulescente del contexto; dicha especie se distribuye en los bosques de *Pinus* y *Quercus*, en los Estados de Guerrero, México y Morelos. Además, se registra a *P. centroamericanus* Sing. & Gómez por vez primera de México en bosques subtropicales del Estado de Veracruz. Por otra parte, se presenta una discusión sobre las especies del género previamente citadas en México.

ABSTRACT

Phylloporus guzmanii Montoya & Bandala is described as new. It is distinguished by the shape and size of the basidiospores, the pileus color and the bluing of the context. It occurs in *Pinus* and *Quercus* forests in the States of Guerrero, Mexico and Morelos. In addition, *P. centroamericanus* Sing. & Gómez is reported for the first time from Mexico where it occurs in subtropical forests from the State of Veracruz. A brief discussion of the previously known species of the genus that occur in Mexico is also included.

INTRODUCTION

The examination of several collections made by the authors and exsiccati from the herbaria at ENCB, FCME and XAL has resulted in the discovery of two new records of *Phylloporus* in Mexico, one of which is new. Microscopic study was carried out with material mounted in 5 % KOH and Melzer's reagent. Colors indicated in the descriptions are taken from the color chart of Kornerup and Wanscher (1984).

Phylloporus IN MEXICO

There are only a few references to this genus from Mexico in the literature. It has been reported mainly from subtropical forests where it is associated with *Quercus* at altitudes of 1000-2000 m and, in a few cases, in *Pinus* or *Abies* forests at altitudes above 2500 m. *P. rhodoxanthus* (Schw.) Bres. ssp. *rhodoxanthus* was the first species to be reported from this country (Singer, 1957; Guzmán, 1977). It is known from several localities in Mexico, particularly from the States of Hidalgo (Frutis & Guzmán, 1983), Jalisco (Téllez-Bañuelos *et al.*, 1988), Michoacán (Díaz-Barriga, *et al.*, 1988), Nuevo León (García & Castillo, 1981; Garza *et al.*, 1985) and Veracruz (Guzmán, 1975; Welden & Guzmán, 1978; Guzmán & Guzmán-Dávalos, 1984).

Other species of *Phylloporus* known to occurr in Mexico are *P. bellus* (Masc.) Corner, reported from Oaxaca (Singer, 1978); *P. coccineus* Corner, from Guerrero (Pérez-Ramírez *et al.*, 1986) which will be discussed below, and *P. phaeoxanthus* var. *simplex* Sing. & Gómez and *P. foliiporus* (Murr.) Sing., both from Veracruz (Singer & Gómez, 1984; Montoya-Bello *et al.*, 1987). Some of the Mexican collections of *P. rhodoxanthus* ssp. *rhodoxanthus* have been reported to have flesh which turns blue when exposed, so they belong to *P. rhodoxanthus* complex but are not conspecific with ssp. *rhodoxanthus*, since Murrill (1946), Corner (1970), Singer (1978), Singer *et al.* (1983) and Singer & Gómez (1984) reported the absence of this character in ssp. *rhodoxanthus*.

SPECIES STUDIED

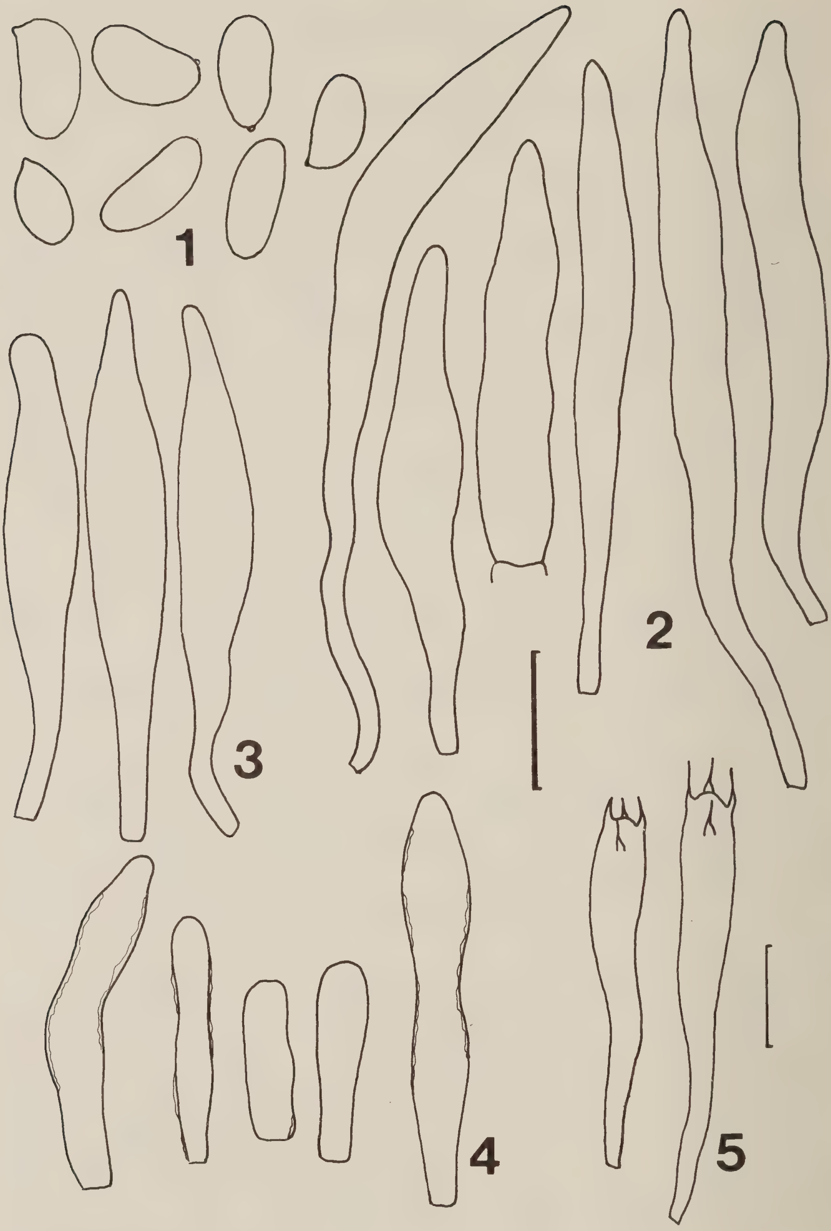
Phylloporus guzmanii Montoya & Bandala *sp. nov.*

Figs. 1-5 & 11-12

Pileo vinaceum, purpureum, rufobrunneum, parce flavobrunneum, subtomentoso, convexo vel applanato, 15-45 (-71) mm lato. Lamellis flavis, viridantibus, subdecurrentibus, subdistantibus et moderatim intervenosis. Stipe pilei concolor, lentis subtomentoso, aequali, 25-50 (-65) x 4-8 mm; velo nulo; mycelio basali flavo. Carne flava, caerulescentes; odore et sabore debil. Sporis (6.4-) 7.2-8.8 (-10.4) x (3.2-) 4-4.8 (-5.6) µm, subellipsoidis vel subglobosis, sub microscopio flavovirens, inamyloideis. Basidiis 47-65.6 x (5.6-) 7.2-8 µm, tetrasporis, claviformibus. Pleurocystidiis (41.6-) 45-105.6 (-116.8) x 5.6-11 (-12) µm, lanceolatis, subfusiformibus vel sublageniformis, flavovirens, tenuitunicatis. Cheilocystidiis 72-80.4 x 6.4-11.2 µm, pleurocystidiis similis. Epicute pilei trichodermium, sublaxus sed non gelatinoso, hiphis elongatis 2.4-3.2 (-4.8) µm crassis. Tramate hymenophorali bilaterali. Hyphis afibulatis. State of Guerrero, Prope Chilpancingo, Omiltemi, sub Pinus-Quercus. Typus Pérez-Ramirez 565 (FCME; Isotipus XAL).

Pileus 15-45(-71) mm in diam., convex to plano-convex, margin undulated, surface velutinous to tomentose, vinaceous red (10D8, 9F7, 9F8), dark purple (10F8) to reddish brown or ferruginous brown (8C8, 8D8, 8F8), with yellowish or yellowish brown tinges. Lamellae decurrent, close to subdistant, intervenose in mature specimens, never poroid, bright yellow (4A7, 4A8, 5A7) to mustard yellow (4B7), bluing (23 F8-24F8) when bruised, bluing areas finally staining reddish brown (7F8, 8E8); margin entire, sometimes with vinaceous red tinges when dried. Stipe 25-50(-65) x 4-8 mm, cylindric, subfibrillose to subvelutinous, concolorous with pileus to brownish (6E6) at base and purplish (9E8, 10D8) toward the apex, sometimes with irregular yellowish tinges; basal mycelium yellow. Context pale yellow (3A5) to mustard yellow (4B7), bluing (23F8-24F8) when exposed. Odor and taste mild. Macrochemical reactions unknown.

Spores (6.4-) 7.2-8.8 (-10.4) x (3.2-) 4-4.8 (-5.6) µm, subelliptic to subalantoid in lateral view, subglobose in frontal view, greenish to yellowish green in KOH, inamyloid, smooth, slightly thick walled (up



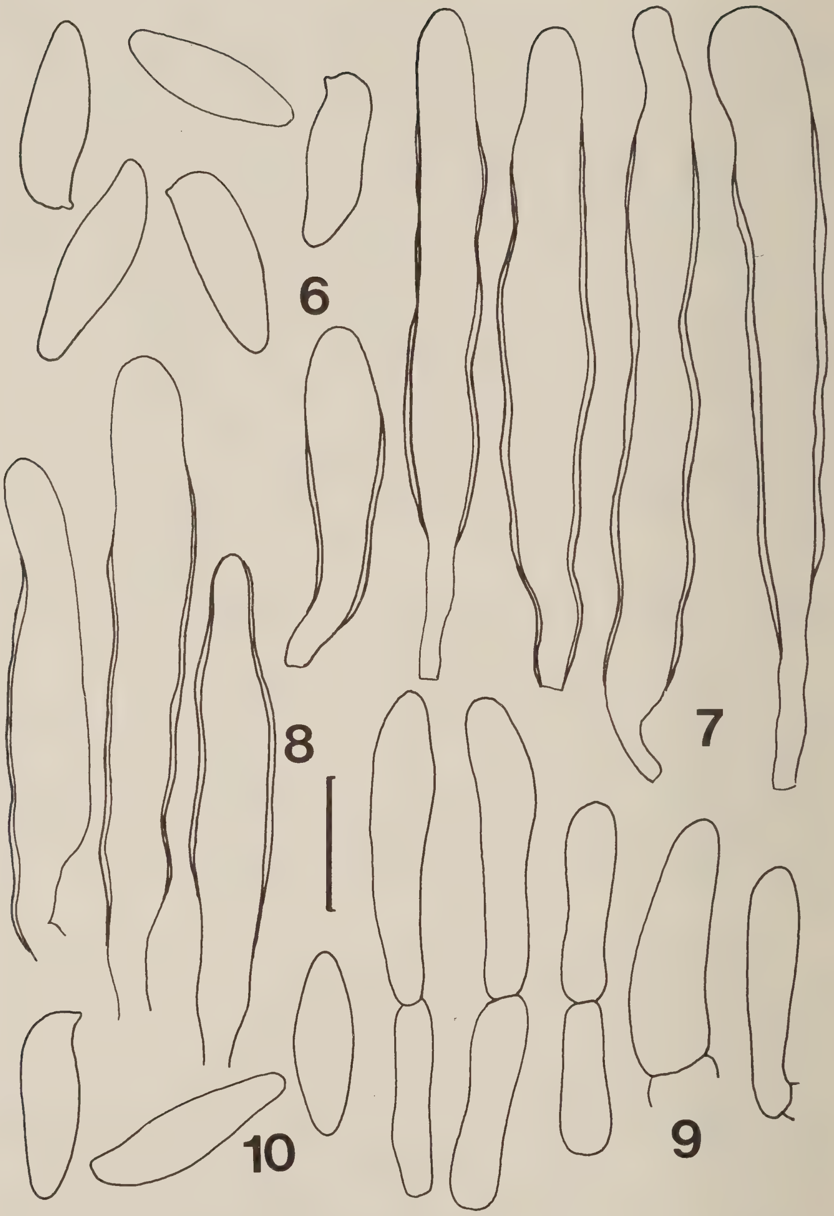
Figs. 1-5: *Phylloporus guzmanii*, 1: spores, 2: pleurocystidia, 3: cheilocystidia, 4: epicutis elements, 5: basidia (all from type) (scale bar, 1= 10 μm; 2-4= 20 μm; 5= 15 μm).

to 0.8 µm thick). Basidia 47-65.6 x (5.6-)7.2-8 µm, clavate, tretrasporic, hyaline, thin walled. Pleurocystidia (41.6-) 45-105.6 (-116.8) x 5.6-11 (-12) µm, lanceolate, subfusiform or sublageniform, often with constrictions, thin walled. Cheilocystidia 72-80.4 x 6.4-11.2 µm, yellowish green, similar to pleurocystidia. Context hyphae 3-8.8 µm wide, cylindric, interwoven, yellowish hyaline, sometimes with dense yellowish content, thin walled, some with pale yellowish green incrustations 0.8(-1.6) µm thick. Hymenial trama bilateral; hyphae yellowish to hyaline, (3.2-)4.8-10 µm wide, thin walled, sometimes with pale yellowish green incrustations which cause the walls to appear thickened. Subhymenium hyphae 2.4-3.2 (-4.8) µm wide, yellowish. Pileus cuticle a trichodermium, with interwoven or suberect chains of elements, tinged yellowish; terminal elements, subclavate to subcylindric, (20-) 22-78 (-80) x 5.6-9.6 µm, thin walled, some intercalary elements with incrustations 0.8(-1.6) µm thick. Hyphae clampless, exuding an intense yellow pigment in KOH.

HABITAT. Terrestrial in subtropical (mesophytic), *Pinus-Quercus* and *Pinus* forests, between 2000 and 2200 m in altitude.

SPECIMENS EXAMINED. STATE OF MEXICO, 10 km from Valle de Bravo, road to Temascaltepec, Guzmán 21880 (ENCB). GUERRERO, Municipio de Taxco, km 2 deviation to Cerro del Huizteco, Wong & Pérez-Ramírez 603 (FCME). Municipio de Chilpancingo, Omiltemi, Pérez-Ramírez 565 (Holotype, FCME; Isotype XAL); Uribe, Aug. 13, 1984 (FCME). MORELOS, Valle del Tepeite, NW Santa María, Valenzuela 4276 (ENCB).

DISCUSSION. This species is characterized by the distinctive shape of the spores, color of the basidiocarp, and the bluing of the context. *Phyllopporus coccineus* Corner from Africa is closely related but is distinguished by the noticeably subglobose spores [7.5-9 (-10) x 6.5-7.5 (-8) µm], broader pleurocystidia (10-18 µm), larger cheilocystidia (-200 x 10-16 µm) and shorter epicutis elements (25-40 µm long) (Corner, 1970). The collections Pérez-Ramírez 565, Uribe, s. n., Aug. 13, 1984 and Wong & Pérez-Ramírez 603 were originally thought to be *P. coccineus Corner* by Pérez-Ramírez *et al.* (1986).



Figs. 6-10: *Phylloporus centroamericanus*. 6 & 10: spores, 7: pleurocystidia, 8: cheilocystidia, 9: epicutis elements (6-9: Montoya 555; 10: Guzmán 29147) (scale bar, 6 & 10= 10 μm; 7-9= 20 μm).

This species is named in honor to Dr. Gastón Guzmán in commemoration of his thirty-five years of dedication to Mexican mycology.

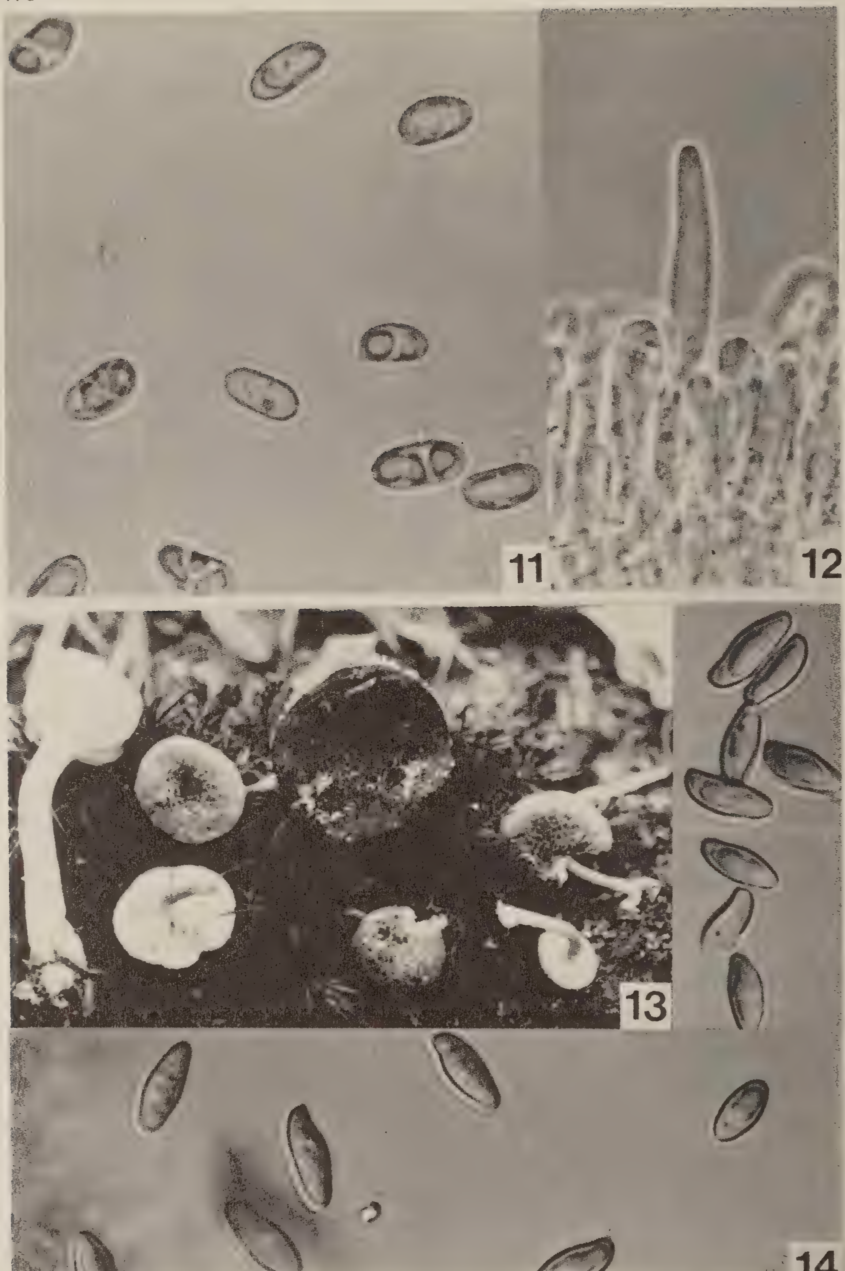
Phylloporus centroamericanus Singer & Gómez, Brenesia 22:169, 1984.

Figs. 6-10 & 13-16

Pileus 7-50 mm diam., plano convex, sometimes depressed toward the disc, dark brown (6F4, 8F4), brown (8F5) or ligth brown with reddish or pinkish tinges (8E6, 8F4), paler toward the margin, velutinous in young basidiocarps, areolate with age revealing the yellow (3A3, 3A5) context. Lamellae adnate to subdecurrent, close, greenish yellow (2A8) or mustard yellow (4A7), slowly or instantaneously bluing (23F8-24F8) when bruised, blue areas eventually staining brown (7F8) to reddish brown (8F8, 9F8); slightly intervenose becoming more so in mature basidiocarps, never poroid. Stipe 16-55 (-65) x 3-7 (-9) mm, cylindric to slightly bulbose toward the base, sometimes sinuous, striate and pruinose in apical region, villous at base to more or less fibrillose-squamose elsewhere, leathery, apex concolorous with lamellae to brown (6F8), reddish brown or vinaceous brown (7F8, 9F8) otherwise, basal mycelium white or whitish. Context yellow (3A6) or pale yellowish brown (5E7) at stipe base, sometimes with irregularly reddish (8E5-8E4) or vinaceous (9F8) stains all over, and sometimes irregularly bluing (23F8-24F8). Odor agreeable; taste mild. Basidiospores olivaceous (4E8, 4F8) in mass.

MACROCHEMICAL REACTIONS. 14 % NH_4OH blue (23F8) on the pileus surface, sometimes negative in usually young basidiocarps or only darkening vinaceous brown (11F4). Pileus surface darkening with 5 % KOH.

Spores (8.8-) 11.2-15.2 (-17.6) x 4-4.8 (-5.6) µm, subfusiform, greenish yellow in KOH, smooth, slightly thick walled (-0.8 µm), inamyloid. Basidia (30.4-) 32-48 x 7.2-10.4 µm, tetrasporic, subclavate, smooth, thin walled. Pleurocystidia (48-) 60-127.9 x (9.6-) 12-16 (-22.4) µm, clavate or subfusiform with constrictions, incrusted, appearing thick walled, apex and base naked, incrustations 0.8-3.2 µm thick; base cylindric (4-) 4.8-8 (-9.6) µm in diam. Cheilocystidia (28-) 50.4-96 (-



Figs. 11-14.- 11-12: *Phylloporus guzmanii*, 11: spores, 12: pleurocystidium (from type; x 400). 13-14: *P. centroamericanus*, 13: basidiocarps (Montoya 1433), 14: spores (Ventura 5608, x400).

97.6) x (9.6-) 12-18 (-20) µm, versiform or similar to pleurocystidia; incrustations 0.8-2.4(-3.2) µm thick, sometimes in patches; base subcylindric, 4.8-8.8 µm wide. Pileus cuticle with interwoven or suberect chains of elements; terminal elements (17.4-) 20-66.6 (-86.2) x (5.6-) 6.4-17.7 (-20.5) µm, subcylindric, some subovoid or subpyriform; some intercalary elements 14.6-18.4 x 11.2-12.8 µm, yellowish or yellowish green, often with yellowish to yellowish orange incrustations. Context hyphae (2.4-) 4.8-14.4 (-16.6) µm, interwoven, yellowish hyaline. Hymenial trama bilateral, hyphae 3.9-14.7 (-16.6) µm wide, yellowish hyaline. Hyphae clampless.

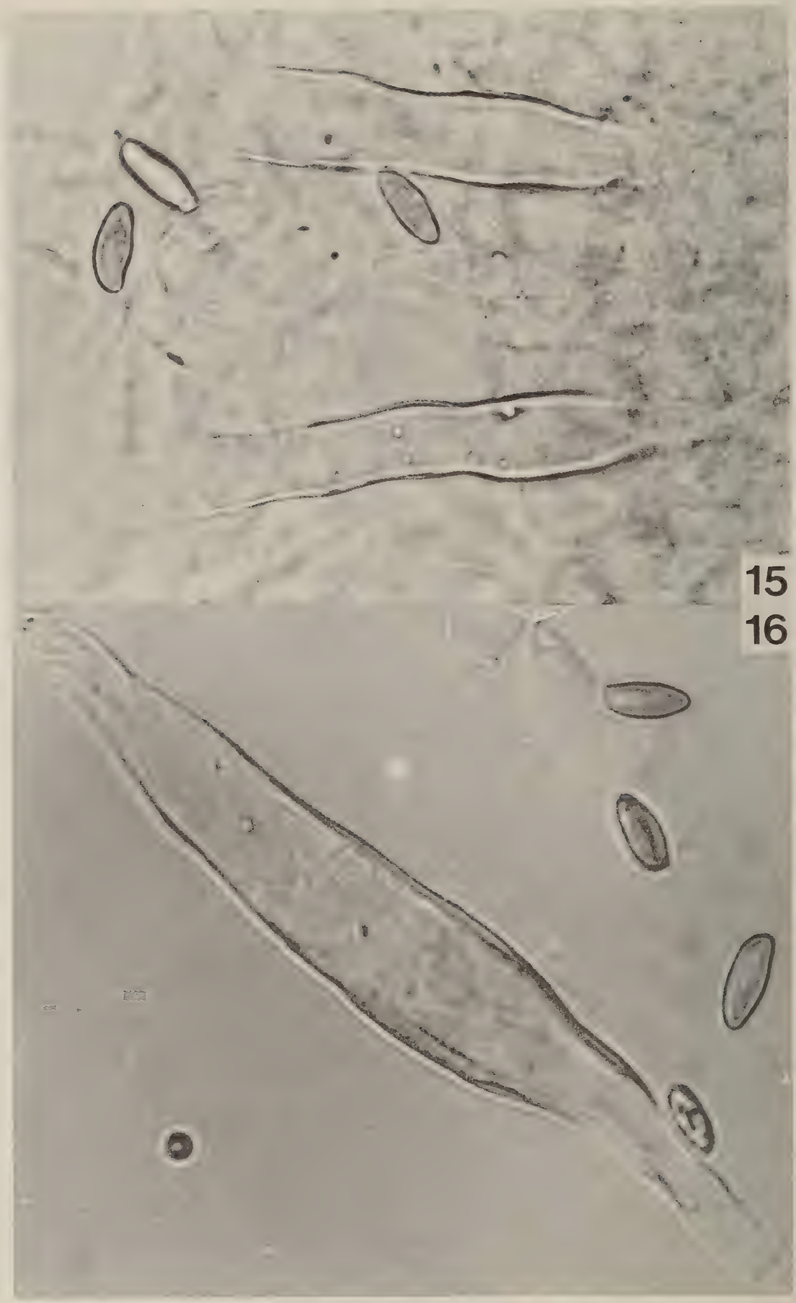
HABITAT. Terrestrial among mosses, often in sandy soil, in subtropical (mesophytic) forests associated with *Quercus*, at 1300-1860m altitude.

SPECIMENS EXAMINED. MEXICO: STATE OF VERACRUZ, 4 km by the deviation to Plan de Sedeño, road Xalapa-Perote, Ventura 5608. 2 km SW from Xalapa, near Coapexpan River, Bandala 1351, 1363, 1367, 1370; Guzmán 29147; Montoya 1397, 1398, 1431. Mpio. de Banderilla, SW Banderilla, Cerro de La Martiníca, Montoya 555; Ortega 11 (all in XAL). COSTA RICA: San José, La Perla, Gómez & Alfaro 20630 (FM).

DISCUSSION. This is the first report of *P. centroamericanus* from Mexico. Singer & Gómez (1984) described the species from Costa Rica. The Mexican material not only agrees well with their description but also with data taken from a specimen studied by them, except, perhaps for the cystidia which are more consistently incrusted.

ACKNOWLEDGEMENTS

The authors express their thanks to Instituto de Ecología and to Sistema Nacional de Investigadores at Mexico for the support given to their researches. Appreciation is also given to Dr. Gastón Guzmán from Instituto de Ecología and Dr. Harry D. Thiers from San Francisco State University, who kindly and critically discussed and revised the manuscript. They also wish to express their gratitude to the curators of the herbaria ENCB, F and FCME for the loan of specimens.



Figs. 15-16: *Phylloporus centroamericanus*, pleurocystidia (15: Gómez & Alfaro 7-1983, x450; 16: Montoya 555, x400).

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TAXONOMICAL STUDIES ON USTILAGINALES. VIII.*

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ABSTRACT

NEW SPECIES proposed: Ustilago gardnerii McKenzie & Vánky (type on Cyperus ustulatus); Ustilago onopordi Vánky (type on Onopordum bracteatum subsp. ilex).

NEW COMBINATION proposed: Ustilentyloma brefeldii (Krieger) Vánky, based on Entyloma brefeldii (type on Phalaris arundinacea).

The following names are considered SYNONYMS: Urocystis castellana (González Fragoso) Zundel (type on Agrostis castellana) is Entyloma dactylidis (Passerini) Ciferri, s. lat. (type on Dactylis glomerata); Urocystis multispora Wang (type on Stipa sp.) is Urocystis granulosa G. P. Clinton (type on Stipa comata); Tuburcinia ranunculi-muricati Viennot-Bourgin (type on Ranunculus muricatus) is Urocystis ranunculi (Libert) Moesz (type on Ranunculus repens); both Ustilago arthurii Hume (type on Panicularia americana), and U. scolochloae Griffiths (type on Scolochloa festucacea) are synonyms of Ustilago echinata Schröter (type on Phalaris arundinacea).

LECTOTYPES are selected for Entyloma podospermi Unamuno & Ciferri, and for Ustilago scitaminea H. Sydow.

On Cruciferae three species of Urocystis are recognized: U. coralloides Rostrup, U. sophiae Griffiths, and U. brassicae Mundkur.

EXCLUDED SPECIES: Sporisorium maydis Cesati (type on Zea mays) is Aspergillus sp.; Thecaphora aurantiaca Fingerhuth (type on Urtica dioica) is a Puccinia sp. (aecia of P. urticae-caricis Klotsch, s. lat., or P. iridis (DC.) Wallroth); Thecaphora pallescens Fingerhuth (type on "Fragaria collina" =? Potentilla sp.) is probably aecia of Frommeella tormentillae (Fuckel) Cummins & Y. Hiratsuka (Uredinales); Tilletia nigrifaciens Langdon & Boughton (type on Phragmites australis) is an ascomycete.

Since finishing the manuscript of my book, European Smut Fungi, I am continuing taxonomical and nomenclatorial investigations of this interesting and economically important group of plant parasitic fungi, in order to pave the way towards a world monograph of Ustilaginales. New results obtained are presented in this current paper, one of a series.

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*Studies in Heterobasidiomycetes, part 89

Entyloma on Scorzonera.

Ciferri (1933:260) published Entyloma podospermi Unamuno & Ciferri on Podospermum laciniatum (L.) DC. (= Scorzonera laciniata L.). In the protologue two syntypes are mentioned: "Ribera de Ortiz, prope Vallisoleti, leg. P. R. Fernandez, V-VI.1926; Caudete, prope Albacete, Hispania, leg. P. Unamuno, IV.1928." In Herbarium MA (Madrid) there are two collections preserved (both under No. 7741). One is identical with the second syntype. The few leaves are heavily infected by aecia of Puccinia podospermi, and apparently devoid of any sori of Entyloma. The other collection is labelled: "Entyloma podospermi Unam. cum Puccinia podospermi in foliis Podospermi laciniati, prope Valladolid ap. fl. Pisuerga, VI.1926, coll. P. Unamuno, Typus." This specimen is more abundant and, besides telia of P. podospermi, contains sori of Entyloma. It is selected here as lectotype. A description of this species, based on the lectotype, is as follows:

Entyloma podospermi Unamuno & Ciferri, in Ciferri, 1933:260.

Lectotype on Scorzonera laciniata L., Spain (sel. here), near Valladolid, at the Pisuerga River, VI.1926, coll. P. Unamuno (MA!). Sori in leaves as small, rounded or angular, yellowish, amphigenous spots, 3–5 mm in diameter. Spores more or less crowded, subglobose to subpolyhedrally irregular, 7–12 x 8.5–14.5 µm, subhyaline to pale yellowish-brown; wall smooth, two-layered, 1–1.5(–2.5) µm thick, equal to slightly unequal.

Urocystis species on Stipa.

Several Urocystis have been reported on Stipa. The following four species can be distinguished:

1. U. fraserii G. P. Clinton & Zundel, in Zundel, 1939:1018. – Type on Stipa comata Trin. & Rupr., Canada, Saskatchewan, Saskatoon, 5.VI.1922, W. B. Fraser & J. W. Scannell (BPI 182124!).
2. U. granulosa G. P. Clinton, 1902:151. – Type on Stipa comata Trin. & Rupr., USA, Idaho, 1859, F. V. Hayden (BPI 182149!).
3. U. stipae McAlpine, 1910:198. – Type on Stipa luehmanni Reader, Australia, Victoria, Mallee, X.1898, C. French.
4. U. corsica (Mayor & Terrier) Vánky, 1982:12. – Sorosporium corsicum (Mayor & Terrier) Guyot & Massenot, in Guyot, Malençon & Massenot, 1969:208. – Type on Stipa tortilis Desf. (= S. capensis Thunb.), Corsica, near Ile-Rousse, VIII.1957, E. Mayor.

U. multispora Wang, 1962:136 (Type on Stipa sp., China, Tsinghai, Char-han-wu-su, alt. 3800 m, 6.VIII.1959, Ma Chi-ming & Hsing Juen-chuang 1304, HMAS 26443; isotype in HUV 7988!) is conspecific with U. granulosa G. P. Clinton.

The main differentiating characters of these species are:

1. Spores per spore ball 1–10 2
– Spores per spore ball 6–20 3
2. Sori in the spikelets. Spores per spore ball 1–10 .... U. granulosa
– Sori in the leaves and stems. Spores per spore ball 1–5(–7) .... U. stipae
3. Sterile cells inconspicuous, thin-walled (0.5 µm). Sori in upper parts of the stems and rachis of the inflorescence .... U. fraserii
– Sterile cells conspicuous, thick-walled (1.5–3 µm). Sori in uppermost leaves and aborted inflorescence .... U. corsica

Urocystis species on Cruciferae.

Four Urocystis (Tuburcinia) have been described on Cruciferae, all producing galls on the roots: U. coralloides Rostrup (type on Turritis glabra); U. sophiae Griffiths (type on Sophia andrenarum); U. brassicae Mundkur (type on Brassica campestris); and Tuburcinia coralloides (Rostrup) Liro var. cantonensis Ciferri (type on Brassica sp.).

The first of these to be described was Urocystis coralloides on the roots of Turritis glabra (Rostrup, 1881:126).

Griffiths (1907:209) describing U. sophiae from the roots of Sophia andrenarum, did not mention the earlier published U. coralloides. Ciferri (1957:93) studied the type of U. sophiae and considered that "it is allied with U. coralloides, the differences being of the same order of the fungus on Brassica in India and in China".

Mitra (1928) reported U. coralloides on Brassica campestris from India. On the basis of differences in the size of the spore balls, spores and sterile cells between the Brassica-smut and the type of U. coralloides, and because infection experiments with spores of Brassica-smut on Turritis and Matthiola gave negative results, Mundkur (1938) described the smut on Brassica as a new species, U. brassicae. My study of the types of U. coralloides and U. brassicae confirms that U. brassicae has spore balls composed of more spores than those in U. coralloides.

Ciferri (1957) studied a specimen of Urocystis on the roots of a Brassica sp. from China. Despite stating that the Chinese specimen "agrees with Urocystis brassicae Mundkur", Ciferri described it as a new variety, var. cantonensis. Ciferri's statement that "The peripherical, sterile cells are about the same number and about the same size of the fertile spores" is evidently erroneous and is in contradiction with what he wrote a few lines below: "The fertile spores are 13–17 µ diam., as a rule 14–16 µ, and the sterile cells smaller, 3–8 µ diam, as a rule 3–5 µ". "Either for biological or biometrical characteristics" Ciferri (1957:93) considered all known species of Urocystis on Cruciferae to belong to Tuburcinia coralloides as "infraspecific taxa" (var. coralloides, var. sophiae, var. brassicae, var. cantonensis).

1. Urocystis coralloides Rostrup, 1881:126.

Tuburcinia coralloides (Rostrup) Liro, 1922:86. – Type on Turritis glabra L., Denmark, Funen, Vejstrup, Aaskov, 5.VI.1880, E. Rostrup (C; isotype HUV 9122!).

"Ustilago coralloides (Rostr.) Rostr." is sometimes cited as synonym of Urocystis coralloides. However, Rostrup never made this combination and the binomial "Ustilago coralloides Rostr.", in Rostrup, 1885:235, is a slip of the pen.

Sori on roots as globose to coralloid galls up to 4 cm in diameter, filled with an agglutinated, black mass of spore balls, hyphae and remnants of host tissue. Spore balls globose, ovoid to irregular, 25–40 x 28–52 µm, composed of 1–4(–5) spores surrounded by a continuous layer of dark, sterile cells. Spores globose, ovoid to elongated, often slightly irregular, 11–19 x 16–25 µm, dark reddish-brown. Sterile cells subglobose to irregular, 5–16 µm long, dark yellowish- or reddish-brown, with smooth, 1.5–4 µm thick wall.

Known on Arabis (incl. Turritis), Lepidium, Matthiola, from Europe.

2. Urocystis sophiae Griffiths, 1907:209.

Type on Sophia andrenarum Cockerell (= Descurainia a. (Cockerell) Cory), USA, Arizona, Tucson, 14.III.1903 (BPI 182515!); paratype: 1.III.1901 (BPI 182516!).

U. sophiae differs from U. coralloides in having lighter coloured spore balls, composed of more spores (1–5), and by the thin-walled (1–2 µm), light coloured sterile cells which often form an incomplete layer around the spores, or sterile cells lacking in the spore balls.

3. Urocystis brassicae Mundkur, 1938:141.

Type on Brassica campestris L. (= B. rapa L.), India, Bihar, Pusa, I.1925, M. Mitra; isotypes in Herb. crypt. Ind. Orient. exs., II. Indian Ust. 32 (HUV 5779!).

U. brassicae has spore balls composed of 1–6(–8) spores, whereas in U. coralloides the spore balls have 1–4(–5) spores.

Known on Brassica rapa L. from Asia. Artificially also on B. juncea (L.) Czern., B. napus L., B. nigra (L.) Koch, B. rapa L. var. lorifolia Bailey, and Raphanus sativus L., Asia.

Probably to this species belongs also Tuburcinia coralloides (Rostr.) Liro var. cantonensis Ciferri, 1957:93. – Type on Brassica sp. cult., China, Canton, 1953.

Yellow-spored Ustilago species on Cyperaceae and Juncaceae.

In connection with a presumably unknown Ustilago species in the capsules of Cyperus ustulatus from New Zealand, kindly sent by Dr. E. H. C. McKenzie, I checked the Ustilago species on Cyperaceae and Juncaceae possessing yellow or light cinnamon-brown spore masses. These are:

1. U. subnitens Schröter & P. Hennings, in Hennings, 1896:215. – Type on Scleria pratensis Lindl., Brazil, Rio de Janeiro.
2. U. cyperi-lucidi Walker, 1971:99. – Type on Cyperus lucidus R. Br., Australia, New South Wales, W. of Pambula, Wyndham, 11.VII.1969, J. Hindle (DAR 17587/a; isotype in HUV 14062!).
3. U. capensis Reess, 1875:70; in Buchenau, 1875:486 + Pl. XI. – Type on Juncus capensis Thunb., and J. lomatophyllus Sprengel, South Africa, Cape of Good Hope (n. v.).
4. U. vuyckii Oudemans & Beijerink, in Oudemans, 1895:55. – Type on Luzula campestris (L.) DC., Netherlands, near Voorschoten, 22.V.1894 (L!, LE!).
5. U. abstrusa Malençon, 1929:256. – Type on Juncus gerardii Loisel., France, Dépt. Manche, Gatteville near Cherburg, 19.IX.1926, G. Malençon (MPU).

The fungus from New Zealand differs from these species, and is described here as:

Ustilago gardnerii McKenzie et Vánky, sp. nov.

Typus in matrice Cyperus ustulatus A. Rich. f. grandispiculosus Kük. ex Carse, New Zealand, North Island, Auckland, Western Springs Lake, 17.II.1989, leg. R. O. Gardner. Holotypus in PDD 57462!, isotypi in BPI & HUV 14850. Paratypi in matrice C. ustulatus, NZ: Auckland, Western Springs Lake, 1. & 15.V.1990, R. O. Gardner (PDD 57731 & 57624 = HUV 15156 & 15160); Taupo, Tokaanu, 5.V.1990, E. H. C. McKenzie (PDD 57584 = HUV 15157); Coromandel, Little Barrier Is., 8. & 10.V.1990, R. E. Beever (PDD 57625 & 57626 = HUV 15158 & 15159); Northland, Whangarei Heads, 31.V.1990, R. O. Gardner (PDD 57463 =HUV 14851).

Sori (Fig. 1) in nuculis tumefactis, massa pulverea pallide, ochraceo-flava sporarum, rupto pericarpio libera refertis. Sporae (Figg. 2, 3) subglobosae, ovoideae usque parum subangulariter irregulares, 13–18(–20) x 15–20(–21) µm, valde subtiliter minuteque interdum incomplete reticulatae, 10–15 maculis per diametrum sporarum, pariete addito reticulo, 2–2,5 µm crasso, muri reticuli 0,8–1 µm alti. Infectio plantarum systematica: nuculae omnes inflorescentiae affectae.

Sori (Fig. 1) in swollen nutlets, filled by a light ochraceous-yellow, powdery mass of spores exposed upon the rupture of the pericarp. Spores (Figs. 2, 3) subglobose, ovoid to slightly subpolyhedrally irregular, 13–18(–20) x 15–20(–21) µm, very finely and minutely reticulate, sometimes incompletely, 10–15 meshes per spore diameter, wall 2–2.5 µm thick including the reticulum, muri 0.8–1 µm high. Infection systemic, all nutlets in the inflorescence being affected.

U. gardnerii differs from U. cyperi-lucidi Walker (Figs. 4, 5) especially by smaller spores, thinner spore wall, and lower muri. In U. cyperi-lucidi the spores measure (12–)16–20(–24) x (15–)17–24(–26) µm, the spore wall is 2.5–4 µm thick, and the muri 1–2 µm high.

The main differences between these species are presented in the following key.

1. On Cyperaceae 2
– On Juncaceae 4
2. On Scleria. Spores smooth . . . . U. subnitens
– On Cyperus. Spores very finely reticulate, 10–15 meshes per spore diam. . . . 3
3. Spore wall 2.5–4 µm thick. Muri 1–2 µm high . . . . U. cyperi-lucidi
– Spore wall 2–2.5 µm thick. Muri 0.8–1 µm high . . . . U. gardnerii
4. On Luzula. Spores deeply reticulate (muri 1.5–2.5 µm high),
5–8 meshes per spore diam. . . . . U. vuyckii
– On Juncus 5
5. Spores shallowly reticulate, 7–12 meshes per spore diam. . . . . U. abstrusa
– Spores (judged from Rees' illustrations) deeply reticulate,
c. 5 meshes per spore diam. . . . . U. capensis

Ustilago species on Compositae.

Dr. Siraj Hasan kindly sent me some smutted Silybum and Onopordum. In connection with the identification of the fungi, I checked the known Ustilago species on Compositae. These are: 1. U. cardui Fischer von Waldheim, 1867:255 (type on Carduus acanthoides L.), 2. U. cichorii H. Sydow, 1929:413 (type on Cichorium intybus L.), 3. U. scolymi Roumeguère & Trabut ex Juel, 1901:257 (type on Scolymus hispanicus L.), 4. U. scorzonerae (Albertini & Schweinitz) Schröter, in Cohn, 1887:274 (type on Scorzonera humilis L.), and 5. U. tragopogonis-pratensis (Persoon) Roussel, 1806:47 (type on Tragopogon pratensis L.). The smut on Silybum marianum is referred to U. cardui, though the spores are somewhat smaller than those of the type specimen, a fact which is considered to lie within the variability of this species. The smut on Onopordum turned out to be an unknown species and it is described as:

Ustilago onopordi Vánky, sp. nov.

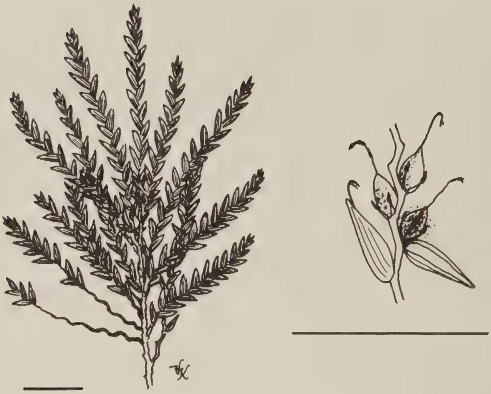
Typus in matrice Onopordum bracteatum Boiss. & Heldr. subsp. ilex (Janka) Franco (syn. O. ilex Janka; det. A. Shepard), Graecia, Thessalia div., Lárisa prov., pr. pag. Halkiades inter Lárisa et Farsala, 5.VII.1989, leg. D. T. Briese & A. Shepard, comm. S. Hasan (HUV 15101); isotypi in BPI, MPU.

Sori (Fig. 6) in floribus achaeniisque evoluti, eos massa sporarum pallide brunneolo-violacea pulverea partim substituentes. Flores omnes eiusdem inflorescentiae infectae. Sporae (Figg. 7, 8) subglobosae, ovoideae usque ellipsoideae, 13,5–17,5 x 14,5–20 µm, subhyalinae usque pallide flavido-brunneae, pariete alte reticulatae, (4–)5–7 maculis per diametrum sporae, muri maculorum 1,5–3 µm alti ad margines sporarum sicut aliae in sectione media autem sporarum sicut projectiones acutae spiniformes apparentes; sub SEM maculae plus-minus rotundatae vel subpolygonales, interstiis levibus. Germinatio (Fig. 9) cum basidio 4-cellulari (4–5 x 25–36 µm), basidiosporas 2–3,5 x 4–6 µm, ovoideas, laterales vel terminales gerenti. Post fusionem basidiosporarum vel cellularum basidii compatibilium, filamenta dicaryotica crescentes. In mediis nutrientibus artefactis e basidiosporis culturae illis fermentorum similes evolventes.

Sori (Fig. 6) in the flowers and seeds which are partly replaced by a pale brownish-violet, powdery spore mass. All flowers in a head are affected. Spores (Figs. 7, 8) subglobose, ovoid to ellipsoidal, 13.5–17.5 x 14.5–20 µm, subhyaline to pale yellowish-brown; wall deeply reticulate, (4–)5–7 meshes per spore diameter, muri 1.5–3 µm high appearing as wings on the spore margin, in median view forming acute, spiniform projections; in SEM meshes more or less rounded or subpolygonal, interspaces smooth. Germination (Fig. 9; on water-agar, at room temperature, in 2 days) results in four-celled basidia (4–5 x 25–36 µm) producing laterally and terminally ovoid basidiospores (2–3.5 x 4–6 µm). After fusion of compatible basidiospores or of basidial cells, dikaryotic filaments result. In nutrient media basidiospores give rise to yeast cultures.

The main differences between the Ustilago species of Compositae are presented in the following key.

1. Spore mass light. Muri in median view spiniform. On Onopordum. . U. onopordi
– Spore mass dark. Muri not so 2
2. Muri over 1.5 µm high. Spores uniformly pigmented 3
– Muri up to 1.5 µm high. Spores often lighter on one side 4
3. Muri in median view appear as radiate marginal wings. Meshes per spore diameter (4–)5–8(–9). On Carduus and Silybum . . . . U. cardui
– Muri not so. Meshes per spore diameter 6–10. On Scolymus . . . . . U. scolymi
4. Spores 10–15 µm long. On Scorzonera . . . . U. scorzonerae
– Spores 13–19 µm long 5
5. Interspaces with evident warts. On Tragopogon . . . . U. tragopogonis-pratensis
– Interspaces without or with inconspicuous warts. On Cichorium . . . U. cichorii



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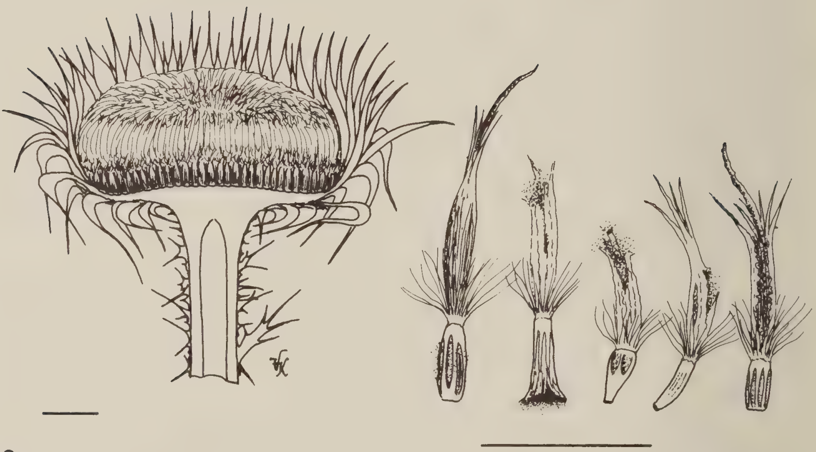
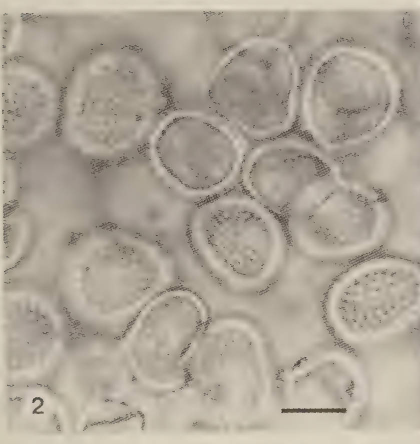


6

Fig. 1. Sori of Ustilago gardnerii in the nutlets of Cyperus ustulatus f. grandispiculosus (type. Bars = 1 cm).
Fig. 6. Sori of Ustilago onopordi in the flowers and seeds of Onopordum bracteatum subsp. ilex (type; bars = 1 cm).
Figs. 2, 3. Spores of Ustilago gardnerii (type) in LM and in SEM.
Figs. 4, 5. Spores of Ustilago cyperi-lucidi (type) in LM and in SEM.
Figs. 7, 8. Spores of Ustilago onopordi (type) in LM and in SEM.

(Bars of LM pictures = 10 μm, those of SEM pictures = 5 μm).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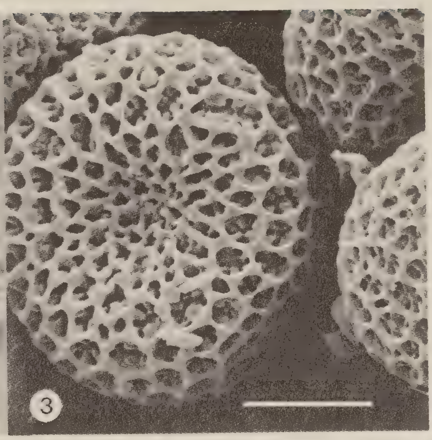
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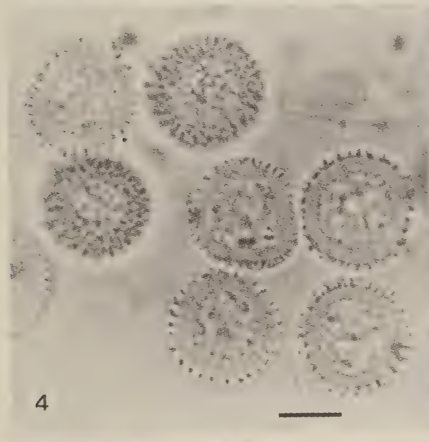
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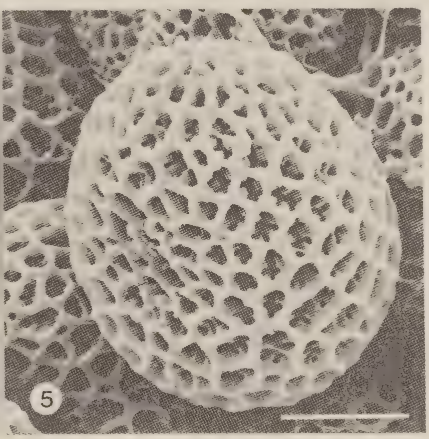
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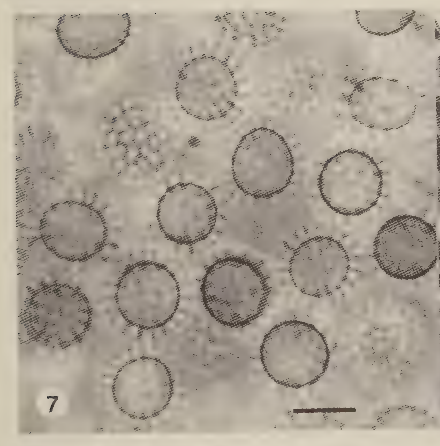
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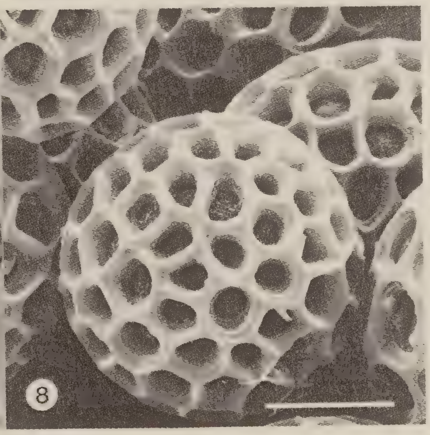
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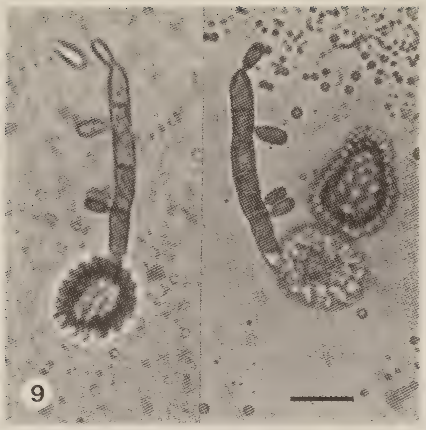

Fig. 9. Germinating spores of Ustilago onopordi (type) (bar = 10 µm).

Ustilago serpens and related species.

Several stripe smuts that were described on Gramineae have spores varying in ornamentation from coarsely echinulate to verrucose or semireticulate. Most of these species have turned out to be synonymous with previously described species. In some cases, the hosts of "new species" were actually misidentified plants. Ustilago arthurii Hume (1902; type on Panicularia americana), and U. scolochloae Griffiths (1904; type on Scolochloa festucacea) were merged by American mycologists under the older name. In spite of the statement by Griffiths (1904:86) that U. scolochloae is "Closely related to Ustilago echinata Schröt." (type on Phalaris arundinacea), they never had been critically compared. A study of the types of U. echinata and U. arthurii revealed no differences in the sorus and spore characteristics and, therefore, they are considered synonyms. In contrast, in spite of the variability in spore morphology, there are some differences between U. echinata and U. serpens (type on Elymus repens), two closely related species (e. g. higher and coarser spines in U. echinata). They were merged by some authors but I prefer to maintain them as separate species (comp. also Vánky, 1985:208). The synonyms and the main characters of these two species are:

1). Ustilago echinata Schröter, 1869:4. – Type on Phalaris arundinacea L., Germany, Schlesien, "Schwarzwasserbruch" near Liegnitz (= Poland, Legnica), VI.1869, W. G. Schneider; isotypes in Rbh., Fgi. eur. 1497 (HUV 3650!).

Ustilago verrucosa Vestergren, 1897:3, (later homonym; non U. verrucosa Schröter, in Hennings, 1896:214). – Ustilago baldingerae Vestergren, in Vgr., Micr. rar. sel. 13, 1899, January. – Ustilago vestergrenii Saccardo & P. Sydow, in Saccardo, 1899:413, August. – Type on Baldingera arundinacea (L.) Dumort. (= Phalaris arundinacea L.), Sweden, Gotland, Björlunds near Källunge, 4.VII.1896, T. Vestergren (HUV 5800!); topotype 9.VII.1898, in Vgr., Micr. rar. sel. 13 (HUV 3651!), and Sydow, Ust. 153 (as U. echinata; HUV 3652!).

Ustilago arthurii Hume, 1902:233. – Type on Panicularia americana (Torr.) MacM. (= Glyceria grandis S. Watson), USA, Iowa, Spirit Lake, 5.VII.1899, J. C. Arthur; isotypes in Seymour & Earle, Econ. fgi., Suppl. C. 135 (HUV 9723!).

Ustilago scolochloae Griffiths, 1904:86. – Type on Scolochloa festucacea (Willd.) Link, USA, Oregon, Harney Valley, Donner & Blitzen River, VII.1902, D. Griffiths & Hunter.

Ustilago arctagrostis Roivainen, 1953(1954):66 (without Latin diagn.), on "Arctagrostis" (sphalm. pro Arctophila) pendulina (Laest.) N. J. Andersson (=

misnamed *Phalaris arundinacea*, comp. Lindeberg, 1959:116), Finland, Ostrobottnia borealis, Tornio, 21.VII.1946, I. Karaila; in Liro, Mycoth. fenn. 790 (HUV 7720!).

Sori in leaf-blades and sheaths as long, often interrupted, conspicuous streaks; the youngest leaves develop typical undulations; the dark brown, semi-agglutinated to powdery spore mass is early exposed. Infection systemic, infected plants do not flower. Spores ovoid to globose, 10–16 x 12–18(–20) µm, olivaceous-brown, provided with conspicuous, irregular, conical, c. 1.5 µm high spines, in some specimens partly anastomosing and forming an irregular and incomplete reticulum.

On *Phalaris arundinacea* L., *Scolochloa festucacea* (Willd.) Link, and *Glyceria grandis* S. Watson: Europe, Asia, North America.

2). *Ustilago serpens* (Karsten) B. Lindeberg, 1959:133. – *Tilletia serpens* Karsten, in Karsten, Fgi. fenn. exs. 599, 1866. – Type on "*Dactylis glomerata* L." (= misnamed *Elymus repens*, comp. Lindeberg, 1959:133), Finland, Merimasku, VII.1862, P. A. Karsten, in Fgi. fenn. exs. 599 (UPS!).

Ustilago macrospora Desmazières, Pl. crypt. Fr., Ed. 2, ser. 1, 1727. 1850 (nomen ambiguum; comp. Nannfeldt, in Lindeberg, 1959:152).

Tilletia aculeata Ule, 1884:213. – *Ustilago aculeata* (Ule) Liro, 1915:34. – Lectotype on *Agropyron repens* (L.) P. Beauv. (= *Elymus repens* (L.) Gould), Germany, (sel. by Lindeberg, 1959:134) Bavaria, Coburg, Festung, VI.1879, E. Ule; isolectotypes in Rbh., Fgi. eur. 3603 (HUV 4488!).

Ustilago elymicola H. Sydow, 1934:286. – Type on *Elymus canadensis* L., USA, South Dakota, Northville, 12.VIII.1927, J. F. Brenckle; isotypes in Sydow, Fgi. exot. exs. 942 (HUV 4506!).

Ustilago michnoana Lavrov, 1936:17. – Lectotype on *Elymus* (sel. by Vánky, 1985:234) *sibiricus* L., USSR, E. Siberia, near Ust'-Kiran, 7.VII.1916, P. Mikhno (LE!).

Sori in leaves and sheaths as short to long streaks between the veins, usually confluent on the youngest leaves and distributed over the whole blade, at first dark lead-coloured, covered by the epidermis, later bursting, the dark brown, semi-agglutinated to powdery spore mass becomes scattered and the leaves often rupture longitudinally. Infection systemic, infected plants remain sterile. Spores ovoid to globose, 12–15(–17) x 13–19 µm, olivaceous-brown, coarsely verruculose, warts 0.5–1 µm high, often grouped or partly confluent; in SEM coarsely verruculose or echinulate, sometimes arranged in an almost reticulate pattern, and finely verruculose between the warts or spines.

On different species of *Elymus* (including *Elytrigia* and *Clinelymus*): worldwide.

NEW COMBINATION PROPOSED

Ustilentyloma brefeldii (Krieger) Vánky, comb. nov.

Basionym: *Entyloma brefeldii* Krieger, in Krieger, Fgi. saxon. 1104, 1896; Hedwigia 35:(145), 1896. – Type on *Phalaris arundinacea* L., Germany, Sachsen, Sächsische Schweiz, Polenzthal, near "Waltersdorfer Mühle", 25.VI.1892, 27.V. & 13.VI.1894, W. Krieger; isotypes in Krieger, Fgi. saxon. 1104 (HUV 9076!).

Entyloma sydowianum Ciferri, 1928:20 (nomen confusum, fide Liro, 1938:98, 385-386).

Entyloma poae Liro, 1938:92 (nomen illeg., diagn. german. tantum); 1939:112. – Lectotype on *Poa pratensis* L., (sel. by Lindeberg, 1959:33) Finland, Helsinki, Seurasaari, J. I. Liro (H); topotype (isotype?) 31.VII.1915, J. I. Liro (HUV 13460!).

The genus *Ustilentyloma* was instituted by Savile (in Savile & Parmelee, 1964:708) for a graminicolous, *Entyloma*-like fungus with a *Ustilago* (not *Tilletia*)-type germination (type *Ustilentyloma pleuropogonis* Savile on *Pleuropogon sabinei* R. Br.). *Entyloma fluitans* Liro on *Glyceria* species was the second graminicolous, *Entyloma*-like fungus with an *Ustilago*-type of germination (Ustilentyloma fluitans (Liro) Vánky, 1970:328). It was suspected, by analogy, that other, light-spored graminicolous "Entyloma" species would have an Ustilago-type of germination, i. e. belong to the genus Ustilentyloma. Indeed, Liro (1938:93) described the spore germination of Entyloma poae Liro, a species morphologically indistinguishable from E. brefeldii. According to Liro the spores of E. poae germinated in water, after a few days, giving rise to four-celled promycelia. Each promycelial cell developed 2–3, up to 15 µm long, hyaline, cylindrical conidia which copulated by pairs.

Ustilentyloma brefeldii is characterised by sori in the leaves and sheaths as inconspicuous, long, whitish, pale green, yellowish or light brown striae along the veins. Infected shoots remain sterile. Spores globose, subglobose, ovoid or rarely irregular, 10–14 x 11–18 µm, subhyaline to light yellow; spore wall smooth, two-layered, even, 1.5–3 µm thick. Germination of Ustilago-type (Liro, 1938:93). Anamorph may be present. It is known from Europe and has been reported on: Arrhenatherum elatius (L.) P. Beauv. ex J. & C. Presl, Calamagrostis arundinacea (L.) Roth, C. canescens (Weber) Roth, C. purpurea (Trin.) Trin., and its subsp. phragmitoides (Hartman) Tzvelev (= C. phragmitoides Hartman), Elymus repens (L.) Gould (= Agropyron repens (L.) P. Beauv.), Holcus lanatus L., H. mollis L., Phalaris arundinacea L., and Poa pratensis L.

Key to the known Ustilentyloma species.

1. Spore wall thick (1.5–3 µm). On several genera of Poaceae . . . . . U. brefeldii
– Spore wall thin (0.5–1 µm) 2
2. Spores 8.5–15.5(–17) µm long. On Glyceria . . . . U. fluitans
– Spores 11.5–19(–21) µm long. On Pleuropogon . . . . U. pleuropogonis

SYNONYMS

Tuburcinia ranunculi-muricati Viennot-Bourgin = Urocystis ranunculi.

Viennot-Bourgin (1968:500) described Tuburcinia ranunculi-muricati and considered it to be different from Tuburcinia ranunculi (Libert) Liro "par les dimensions relatives des cellules fertiles par rapport aux cellules stériles, et aussi par l'organisation du glomérule." For his species, Viennot-Bourgin gave spore dimensions of 14–16 µm, and for those of sterile cells 4–8 µm. Comparing the types of T. ranunculi-muricati and Urocystis ranunculi (Libert) Moesz, I could not find any essential differences. In T. ranunculi-muricati Viennot-Bourgin (type on Ranunculus muricatus L., Iran, Gilan prov., Bandar-e Pahlavi, V.1967, coll. Mirkamali; IRAN, isotype HUV 15122!) the spores measure 11–15 x 12–21.5(–24) µm, the sterile cells 5–10.5(–13) x 8–17 µm, the number of spores per spore ball is 0–4 (0=1.5%, 1=56.5%, 2=34.5%, 3=6.5%, 4=1%). In Urocystis ranunculi (Libert) Moesz, 1950:213 (based on Sporisorium ranunculi Libert, Pl. crypt. Ard. Ed. 2, 195, 1832, type on Ranunculus repens L., France, Dépt. Ardennes; isotypes in Libert, Pl. crypt. Ard. Ed. 2, 195, HUV 9265!) the spores measure 10.5–15 x 12–22.5 µm, the sterile cells 6.5–10.5(–11) x 7–14.5(–16) µm, the number of the spores per spore ball is 0–5 (0=1.5%, 1=61%, 2=28.5%, 3=6.5%, 4=2%, 5=0.5%). Consequently, I consider Tuburcinia ranunculi-muricati Viennot-Bourgin to be a synonym of Urocystis ranunculi (Libert) Moesz.

Urocystis castellana (González Fragoso) Zundel = Entyloma dactylidis (Pass.) Cif. González Fragoso (1926:101) described and illustrated Tuburcinia castellana Gz. Frag. on Agrostis castellana Boiss. & Reuter, Spain, Guadarrama Mts., near El Aular, 1.VIII.1925, S. Corona (MA 1677!). The study of the type specimen, and of the illustration of the "spore balls", revealed that it is Entyloma dactylidis s. lat.

LECTOTYPIFICATION

When H. Sydow (1924:281) demonstrated that the sugarcane smut is different from Ustilago sacchari Rabenhorst (type on Erianthus ravennae), he described it as Ustilago scitaminea on Saccharum officinarum from East India, Java and the Philippines, without designating a type. As lectotype, I am proposing one of the sugarcane smuts distributed in Sydow's exsiccata, namely that from E. India, Bhagalpur, Bengal, 26.VIII.1907, E. J. Butler (HUV 4454!); isolectotypes in Sydow, Ust. 384 (as *Ustilago sacchari*). Syntypes on *Saccharum officinarum*, Java, Djatibarang, 1898, M. Racoborski, in Sydow, Ust. 406 (as *U. sacchari*; HUV 4455!); E. India, Pusa, 20.II.1913, E. J. Butler, in Sydow, Fgi. exot. exs. 119 (as *U. sacchari*; HUV 4456!).

Ustilago scitaminea H. Sydow is characterised by: Sori in floral stems which are transformed into long, leafless, flagelliform, often curved bodies, basal part of the sori concealed by leaf sheath, free and tapering distally, first covered by a silvery membrane of host tissue which flakes away disclosing the blackish-brown, dusty mass of spores intermixed with irregular groups of sterile cells. Spores globose, subglobose to subovoid, 5.5–7.5 x 6.5–8(–9) µm, reddish-brown; wall uniform, 0.5–0.8 µm thick, from nearly smooth, finely and sparsely punctate-verruculose to sparsely or moderately densely echinulate. Sterile cells variable in form and size, larger than the spores (8–23 µm in diameter), yellow or pale yellowish-brown, smooth.

In addition to *Saccharum officinarum* L., *Ustilago scitaminea* was also reported on other *Saccharum* species. Two varieties of *U. scitaminea* were also described, mainly on the basis of slight differences in spore measurements and surface ornamentation. These data must be verified.

The presence of groups of sterile cells between the spores are not characteristic for *Ustilago*. Further studies may show the necessity of a generic recombination.

EXCLUDED SPECIES

Sporisorium maydis Cesati, Diar. Synh. Phys. Ital. 1844 ad diem 23. Sept. (n. v.); in Rabenhorst, Herb. viv. myc. 1070, 1848 (HUV 13282!). Type in immature seeds of *Zea mays* L., "In Insubria legit Cesati". It is an *Aspergillus* sp. (det. F. Spaay), being present both anamorph and teleomorph (cleistothecia, which may belong to the same sp.), associated with acari.

Fingerhuth (1836) describing *Thecaphora*, published three new species: 1. *T. hyalina* Fingerh., in the seeds of *Convolvulus sepium* L., 2. *T. aurantiaca* Fingerh., on the leaves of *Urtica dioica* L., with the description "Thecis pentagonis flavo-aurantiacis, sporidiis minutis oblongis (Ich lasse hier das sogenannte peridium spurium . . . . . unberücksichtigt)", and 3. *T. pallescens* Fingerh., on the leaves of *Fragaria collina* Ehrh. "Thecis pentagonis majusculis flavescentibus, sporidiis oblongo-ovatis vel subglobosis." The first species, *T. hyalina*, was selected by Clements & Shear (1931) as typus generis. The second and third species are certainly aecia of rust fungi; probably *Puccinia urticae-caricis* Klotzsch, s. lat., or *P. iridis* (DC.) Wallr. on *Urtica*, and of *Frommeella tormentillae* (Fuckel) Cummins & Y. Hiratsuka (Uredinales) on "*Fragaria collina* Ehrh." (= probably misidentified *Potentilla* sp.).

Langdon & Boughton (1978:457) described an unusual *Tilletia* species, *T. nigrifaciens*, producing external sori on the surface of the leaves of *Phragmites australis* (Cav.) Trin. ex Steudel (type: Australia, Queensland, Logan River, 18.V.1974, R. F. N. Langdon, BRIU 2533; isotype HUV 7178!). An external sorus is typical for the smut genera *Orphanomyces* Savile and *Clintamra* Cordas & Durán, and also occurs in some species of *Ustilago*, e. g. in *U. hypodytes* (Schlecht.) Fries, s. lat. External sorus was previously unknown in *Tilletia* and this lead me to investigate the type of *T. nigrifaciens*. The globose or subglobose, brown spores of 18–24 µm diameter, possessing a reticulate, 1–4 µm thick wall with a thin gelatinous sheath, and the presence of hyaline "sterile" cells of 16–32 µm diameter fit well with the characters of a typical *Tilletia*. The spore germination is not known. However, study of the ultrastructure, kindly executed by Dr. R. Bauer, solved the problem: the septal pore is simple and Woronin bodies are present demonstrating that the fungus is an ascomycete.

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ABBREVIATIONS

The abbreviations for herbaria follow Index Herbariorum (Stafleu, 1981).

HMAS = Herb. Institute of Microbilolgy, Academia Sinica, Bejing, China.

HUV = Herb. Ustilaginales Vánky, the author's private herbarium.

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ENTOMOPHTHORA CHROMAPHIDIS (ENTOMOPHTHORALES): THE CORRECT IDENTIFICATION OF AN APHID PATHOGEN IN THE PACIFIC NORTHWEST AND ELSEWHERE

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A survey for fungal pathogens of cereal aphids in the Pacific Northwest of the United States found several entomophthoraleans. A species of *Entomophthora* (in the strict sense) causing minor early-season mortality of aphids was of special taxonomic interest. Evaluation of this fungus indicated that it was best identified as *E. chromaphidis* Burger & Swain, a species long treated as a synonym of *E. planchoniana* Cornu. *E. chromaphidis* has primary conidia that are appreciably smaller than those of European collections of *E. planchoniana*, and can be isolated in culture whereas similar media and techniques have never yielded cultures of *E. planchoniana*. This study recognizes the aphid-pathogenic species of *Entomophthora* to comprise a globally distributed species complex; *Entomophthora planchoniana* is a major pathogen whose distribution is primarily European whereas *E. chromaphidis* appears to be a comparatively minor pathogen with a wide distribution outside of Europe.

Key Words: Entomophthorales, *Entomophthora planchoniana*, *Entomophthora chromaphidis*, aphid pathogens, cereal aphids, *Metopolophium dirhodum*, *Schizaphis graminum*, *Sitobion avenae*.

Surveys for fungal pathogens of cereal aphids on wheat in southwestern Idaho found several entomophthoralean fungi attacking these host species during the years 1986-1989 (Feng et al., 1990). No aphid infected by any fungus resembling *Entomophthora planchoniana* Cornu (MacLeod *et al.*, 1976) was found until late

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October 1988. At that time, a single cadaver of *Schizaphis graminum* (Rondani) discharging the campanulate conidia of an *Entomophthora* species (sensu Remaudière & Keller, 1980) was collected from winter wheat at the Southwestern Idaho Research and Extension Center at Caldwell. In July 1989, this *E. planchoniana*-like fungus was found attacking *Metopolophium dirhodum* (Walker) and *Sitobion avenae* (F.) on irrigated spring wheat at the Southwestern Idaho Research and Extension Center at Parma and also on *M. dirhodum* collected from spring wheat at Prosser, Washington.

This *Entomophthora* sp. was the earliest-occurring pathogen of aphids on wheat in 1989 but was soon replaced by *Pandora neoaphidis* (Rem. & Henn.) Humber, *Conidiobolus obscurus* (Hall & Dunn) Rem. & Kell., and *Conidiobolus thromboides* Drechs.. The incidence of this *Entomophthora* sp. never exceeded 2.5% in laboratory rearings of weekly field collections of *M. dirhodum*, and was even lower in similar laboratory rearings of *S. avenae*.

The color of aphids freshly killed by the fungus from Idaho and Washington varied among the host species but was typically yellowish or reddish brown. The general morphologies of the conidiophores (Fig. 1a), primary and secondary conidia (Figs. 1b-e), hyphal bodies (Fig. 1f), and stout bundle of rhizoids terminating in a spreading plate (Fig. 1g) strongly resembled those of *E. planchoniana* Cornu, the only *Entomophthora* species generally recognized from aphids.

In most circumstances, the fungus from Idaho and Washington would be automatically identified as *E. planchoniana*. However, as noted in Table 1, primary conidia from the Idaho and Washington collections were (12.5)-14.4-(16.3) × (10.3)-12.3-(13.5) µm (n=40; 8 conidia mounted in aceto-orcein from each of 5 individuals of *M. dirhodum*). These conidia were notably smaller than the sizes – (14)-19-(23) × (12)-14-(19) µm – recorded from European collections of *E. planchoniana* reported by MacLeod *et. al.* (1976). *E. planchoniana* was described from France (Cornu, 1873) and has always been most commonly reported from Europe. The importance of this discrepancy in conidial size was underscored by the fact that a similarly small-spored species from California was described as *Entomophthora chromaphidis* Burger & Swain (1918), and that still another fungus with such small conidia from Australia was tentatively identified as *E. planchoniana* and cultured *in vitro* (Holdom, 1983, 1984).

Burger and Swain (1918) reported that *E. chromaphidis* caused significant mortality of walnut aphids, *Chromaphis juglandicola* (Kalt.), in southern California. Although the campanulate primary conidia of *E. chromaphidis*, at 11-14 × 10-11 µm, are distinctly smaller than the variable European collections of *E. planchoniana* (Table 1), this species is usually synonymized with *E. planchoniana* (Gustafsson, 1965; MacLeod *et al.*, 1976; Waterhouse and Brady, 1982). Unfortunately, Burger and Swain (1918) preserved no type or authentic specimens of *E. chromaphidis*, and we have been unable to obtain infected *C. juglandicola* from the few remaining walnut groves near Riverside, California, the locality in which Burger and Swain found their fungus. The identity of the fungus from the Pacific Northwest and the status of *E. chromaphidis* became the major concerns of this study.

Despite the unavailability of enough diverse collections of aphid-pathogenic *Entomophthora* material to seek biochemical confirmation for the separation of these apparently distinct morphs, several characters suggest a functional need to recognize two related species, *E. planchoniana* and *E. chromaphidis*: These characters include the sizes of primary conidia and conidial nuclei, and the rela-

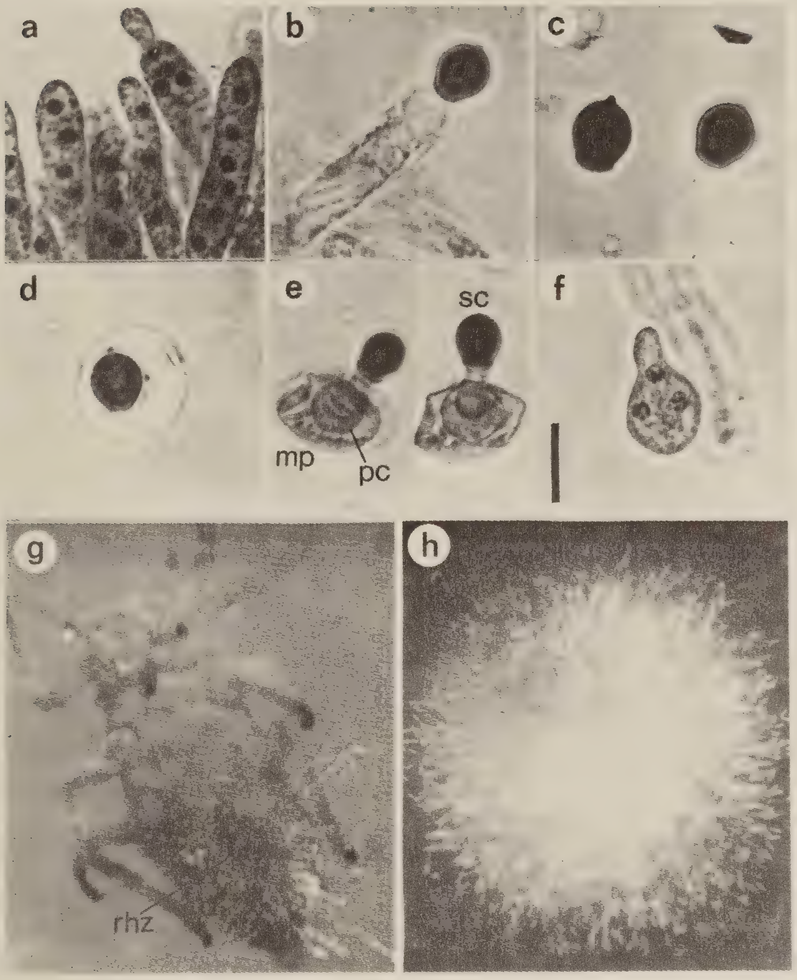

FIGURE 1. Morphology of *Entomophthora chromaphidis* infecting cereal aphids.

(a) Developing conidiophores; **(b)** mature 5-nucleate conidium and conidiophore containing residual cytoplasm; **(c)** primary conidia; **(d)** primary conidium embedded in mass of discharged protoplasm; **(e)** secondary conidia [sc] forming on primary conidia [pc] embedded in discharged protoplasm [mp]; **(f)** germinating conidium; **(g)** pseudorhizomorphic bundle of rhizoids [rhz] spreading into a terminal plate on the substrate.; **(h)** hyphal bodies in Grace's medium + 10% fetal bovine serum. **Fiduciary bar:** a-f = 15 μm, g-h = 0.3 mm. **Stains:** aceto-orcein in a,b,c (right), f; with cotton blue in c (left), d, e.

tive ease with which the fungus may be isolated and grown *in vitro*. Other characters that seem to separate these taxa, *e.g.*, the relative virulence and host spectrum, may be artifacts influenced by local climatic factors and/or geographic differences in distribution of particular aphid species.

Primary conidial morphology and nuclear characteristics: Figures for the dimensions of primary conidia of *Entomophthora* species from aphids collected in diverse locations on three continents are shown in Table 1; references to collec-

TABLE 1. Comparative sizes of primary conidia and nuclei in collections of *Entomophthora* species affecting aphids.

Country	Mean [Range] (µm)	Nuclear diameter (µm)	Reference
Australia			
Queensland	[14-20 x 13-18]	—	Milner *et al.*, 1981
Queensland	15 x 13 [13-19 x 11-15]	4-5[a]	Holdom, 1984
Chile	17.5 x 14.6 [14.1-18.0 x 13.2-15.8]	—	Aruta *et al.*, 1974
Finland	18.8 x 15.5 [16.7-20.5 x 14.1-17.9]	—	Papierok & Havukkala, 1986
	19.5 x 15.4 [15.4-21.8 x 11.5-17.9]	—	Papierok & Havukkala, 1986
	18.1 x 14.9 [13-22 x 10-18]	—	Papierok, 1989
Sweden	19 x 15 [16-22 X 13-17]	—	Gustafsson, 1965
Switzerland	15.5-19.5 x12.5-16 [15-23 x 11-19]	3.3-3.5[b] 2.5-2.8[c] 2.8[d]	Keller, 1987
UK – England			
	[17-23 x 12-20]	—	Petch, 1937
	18 x 13 [14-20 x 11-15]	—	Byford & Reeve, 1969
USA			
California	[11-14 x 10-11]	—	Burger & Swain, 1918
Idaho/Washington	14.4 x 12.3 [12.5-16.3 x 10.3-13.5]	3.5-4.5[b]	[this study]
Montana	18.9 x 15.5 [5.0-22.5 x 12.0-17.8]	—	Feng *et al.*, 1991

[a] from cultures; [b] in aceto-orcein; [c] after Feulgen reaction; [d] from histological sections

tions identified as *Entomophthora planchoniana* from several countries are omitted if they included no information about conidial sizes.

MacLeod *et al.* (1976) reported that conidia of [European material of] *E. planchoniana* contain 4-6 nuclei. Collections referable to *E. chromaphidis* have a similar number of conidial nuclei. Four to six nuclei were found in 82.5% of conidia from the Pacific Northwest; 3, 7, and 8 nuclei were found in 7.5%, 5%, and 5% of the conidia, respectively. Holdom (1984) reported 5-9 nuclei in the small-spored Australian fungi.

The conidial nuclei of the Idaho/Washington fungus (mounted in aceto-orcein) were 3.5-4.5 µm in diameter. Nuclei in histological sections of aphids infected by a British strain of *E. planchoniana* (Brobyn and Wilding, 1977) are estimated to be 3.2–4.6 µm in diameter; this is appreciably larger than the diameter of 2.8 µm nuclei in similarly treated Swiss material (Keller, 1987). It should be noted that the sizes of structures in fixed, embedded, and sectioned material of entomophthoralean fungi tend to be appreciably smaller than in fresh material (Humber, 1976).

So few of the collections in Table 1 include information about nuclear sizes in the primary conidia because the taxonomic values for *Entomophthora* species of both the number and size of conidial nuclei were only recently noted (Keller, 1986) but has not yet been universally adopted. Only the study of more numerous and diverse collections of both large- and small-spored fungi will determine whether the number and size of conidial nuclei differ appreciably in *E. chromaphidis* from those reported for *E. planchoniana*.

***Natural incidence of* Entomophthora *on aphids*:** Dean and Wilding (1971, 1973) noted that *E. planchoniana* caused heavy mortality of *M. dirhodum* and *S. avenae* in southcentral England from early June throughout the summer although these mycoses were most prevalent at the beginning and end of the season (Dean and Wilding, 1971). A similar bimodal incidence of *E. planchoniana* was noted for several aphid species in France (Remaudière *et al.*, 1981). In Europe, *E. planchoniana* is often noted to be a major pathogen occurring during the warmest (middle) part of the summer (Wilding, 1975; Keller, 1980), and has been noted to be a minor pathogen of aphids on potatoes in the United States during mid summer (Shands *et al.*, 1962).

Entomophthora infections of aphids are relatively rare in North America and, seemingly, many other parts of the world (Thaxter,[1] 1888; Hutchison, 1963; Remaudière *et al.*, 1978). By comparison, *E. planchoniana* (sensu stricto) is a very common aphid pathogen in Europe (Gustafsson, 1965; Thoizon, 1970; Dean and Wilding, 1971; Remaudière *et al.*, 1981).

The collection in Montana (Feng *et al.*, 1991) as well as in Australia (Milner *et al.*, 1981) of an *Entomophthora* species that appears to be indistinguishable from *E. planchoniana* (s.str) raises the possibility that the geographical ranges of *E. planchoniana* and *E. chromaphidis* may overlap in some regions even though no small-spored fungus corresponding to *E. chromaphidis* has yet been reported from Europe.

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[1] *E. planchoniana* as discussed in Thaxter's (1888) monograph was a misidentification of *Conidiobolus obscurus* (Hall & Dunn) Remaudière & Keller. Despite his several years of collecting at many locations in the eastern US, Thaxter apparently found no entomophthoralean pathogen of aphids with conidia resembling those of *E. muscae*.

***Culturability* in vivo:** The first culture of an *Entomophthora* from aphids was identified as *E. planchoniana* by Holdom (1983) although this fungus had conidia whose small size is comparable to that of *E. chromaphidis* and the fungus from Idaho and Washington (see Table 1). The Australian fungus was isolated easily and repeatably by dispersing hyphal bodies from surface-sterilized aphids into a liquid medium containing neopeptone (2%), glucose (5%), and fetal bovine serum (10%); sporulation was induced by spreading hyphal bodies on SEMA (Sabouraud dextrose agar + egg yolk +milk) (Holdom, 1983,1984).

An *in vivo* colony of the Idaho fungus was established by adding sporulating field-collected cadavers of *M. dirhodum* and *S. avenae* to a cage of healthy aphids; this laboratory colony was the source of infected cadavers for attempts to establish axenic cultures. Cadavers from which the fungus had not yet emerged were surface-sterilized in 1% NaOCl, rinsed in sterile distilled water, and placed individually into drops of Grace's insect tissue culture medium supplemented by 10% fetal bovine serum in a 60 mm Petri dish; cadavers were crushed with a glass needle to release fungal contents into the medium. Coarse hyphal bodies appeared in the liquid (Fig. 1h) after 24-40 hr of incubation at 20°C in a 16:8 light:dark cycle and were transferred to 5 ml of the same medium in tissue culture flasks for further incubation under the same conditions of temperature and light. Unfortunately, all cultures so obtained were overcome by bacterial contamination during shipment to Ithaca, NY, and lost before they could be purified and accessioned into the USDA-ARS Collection of Entomopathogenic Fungal Cultures (ARSEF; Ithaca, NY).

In sharp contrast to the successful attempts to isolate cultures from the small-spored *Entomophthora* species, periodic attempts (by RAH) to culture the British material of the large-spored *E. planchoniana* from N. Wilding's *in vivo* laboratory colony of this fungus on *Aphis fabae* using virtually identical materials and culture techniques have consistently failed to yield cultures.

The widely accepted concept of *E. planchoniana* given by MacLeod *et al.* (1976) must be questioned in view of the evidence supporting the restoration from synonymy of *E. chromaphidis* and the identifications of *E. planchoniana* from non-aphid hosts. Byford and Reeve (1969) noted a species of *Bradysia* (Diptera: Mycetophilidae) to be infected by *E. planchoniana*.[2] Ben-Ze'ev *et al.* (1981) reported Israeli collections identified as *E. planchoniana* (but without supporting morphological data) from unidentified insects belonging to the Cercopidae, Cicadellidae, and Membracidae, three families of the Homoptera that are quite distinct from the Aphididae. No morphological data about these non-aphid hosts was published. Such unexpected identifications of *E. planchoniana*, however tentative, coupled with continuing effort to resolve the *Entomophthora muscae* species complex (Humber, 1990) suggest that the species of *Entomophthora* deserve continued and serious taxonomic study in the future.

All available data suggest that the small-spored *Entomophthora* species from aphids in California, Idaho, Washington, and Australia are more accurately identified as *E. chromaphidis* than as *E. planchoniana* and that the former species must be restored from its status as a synonym of the latter species. Such a decision treats *E. chromaphidis* and *E. planchoniana* as members of a globally distributed complex of *Entomophthora* species attacking aphids and insects from other families and orders.

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[2] This fly pathogen is probably more properly referred to the unresolved species complex centering on *E. muscae* (Cohn) Fres. (Keller, 1984; Eilenberg *et al.*, 1987).

We regard the evidence presented here for accepting *E. chromaphidis* as distinct from *E. planchoniana* to be substantial enough to require the taxonomically conservative course of recognizing both of these distinctive forms. Future reports of these species should be careful to report primary conidial dimensions and the number and size of the conidial nuclei as well as the dates, ambient temperatures, and other climatic parameters prevailing during outbreaks of aphid-pathogenic *Entomophthora* species. Concerted attempts should be made to obtain *in vitro* cultures of both large- and small-spored forms using the tissue culture media and hyphal body inocula that have proven so successful with many other fastidiously pathogenic species of the Entomophthorales.

The definitive resolution of the species complex including *E. planchoniana* and *E. chromaphidis* will require thorough morphological, developmental, and molecular characterizations of collections from a wider range of hosts and geographical sites than have yet been available.

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MYCOTAXON

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A redescription of Peziza bananicola and comments on some similar tropical species[1]

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This brief note reports on *Peziza bananicola* (Rehm) Saccardo, a tropical species, first described from a collection made by C. F. Baker in the Philippines in 1913. My examination of the pertinent literature has failed to uncover any additional reports of the species. I discussed *P. bananicola* briefly in my type studies of taxa assigned to *Peziza* (Pfister 1979). Subsequently Vincent Demoulin collected an unusual *Peziza* in Papua New Guinea that ultimately was sent to me. It has proven to be *P. bananicola*. Demoulin's large collection, both dried and in alcohol, has allowed for a more complete description of the species. *Peziza bananicola* can now be compared more closely with similar fungi known from Africa.

Species assigned to the genus *Peziza* are often poorly known. Because certain ephemeral characters, such as color and reaction of the ascomata when damaged, are used in identifying species, knowledge of species is often fragmentary, particularly if descriptions are based on dried specimens. Species such as *P. bananicola*, known only from brief descriptions prepared from dried material, prove to be problematic. Moreover, there is no workable infrageneric taxonomic framework in which to place species. *Peziza bananicola* and two taxa described by Le Gal, mentioned in the notes, are similar morphologically and should, when disposition of taxa is possible, be placed in close proximity.

Peziza bananicola (Rehm) Saccardo, Syll. Fung. 24: 1160. 1928.
= *Plicaria bananicola* Rehm, Leafl. Philip. Bot. 6: 2234. 1914.

Ascomata concave, cupulate but becoming convoluted in some examples, gregarious, sessile or with very short stipes, 5 to 7 cm in diam, situated on a whitish subiculum. Hymenium whitish or rose or yellowish, outer surface concolourous. Subiculum composed of broad, thin-walled, sparingly-branched hyphae, no conidiogenous cells noted. Excipulum of several layers, as follows (listed in order from the subhymenium): I. a distinct subhymenium composed of interwoven hyphae; II. a layer of globose, pyriform cells from 40-80 μm in diam; III. a layer of interwoven hyphae 15-25 μm in diam; IV. a layer of globose and pyriform cells similar to those described in II, above; V. the outer layer of the apothecium composed of densely interwoven hyphae 14-18 μm in diam, which give rise to loose

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[1] Publication no. 234 from the Laing Island Biological Station.

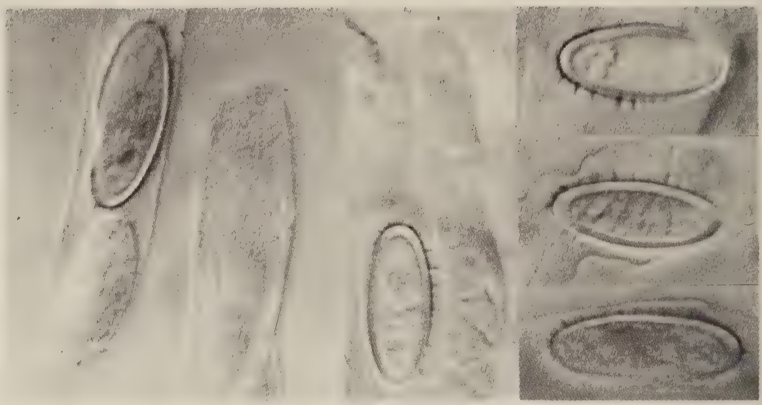

Figure 1. *Peziza bananicola*. Left, ascospores and asci; center, ascospore with a paraphysis; and right, ascospores. x 1000.

hyphal tips that cover the outer surface. The asci are cylindrical and diffusely J+, 100-330 x 13-14 μm, 8-spored, with crozers at the base. Ascospores narrow elliptical, often with walls up to 2 μm thick particularly when young, 20-24 x 8.8-12μm, covered with sparse, irregularly spaced spines what are particularly prominent at the poles. Paraphyses straight, septate, 8-9 μm broad at the apex.

Associated with debris from banana plants.

Specimens examined: Holotype. *Ad bananam emortuam*, Luzon, Prov. Laguna, Los Baños, 7/1913, leg. M. B. Raimundo, comm. C. F. Baker. (S). New Guinea: Extrémité NW des Monts Finistèrre piste Madang-Lae, un peu au S. de la vallée du Gogol, Lat./Long. env. 5° 20' S/145° 30' E. Base d'un tronc de bananier vivant, 16.12.1979. V. Demoulin (5529) and L. Smeets. (LG and portion FH, LAE).

Demoulin's collection has allowed for a much more complete picture of the anatomy of this species. Two distinctive characteristics mark this species -- the extensive whitish subiculum and the peculiar ornamentation of the ascospores. The subiculum is prominent; it covers and binds the substrate. An extensive subiculum such as this does not often occur in the genus *Peziza*. Among tropical taxa the only mention of a subiculum known to me is that of *Galactinia tapesioides* Le Gal (1959). *Galactinia tapesioides* was described from Africa from woody and other debris. It has spore ornamentations and hymenial colors that are similar to *Peziza bananicola* but the spore ornamentations seem to lack the acutely pointed apices found in *P. bananaicola*. In addition to *G. tapesioides* there is another African species, *G. luteorosella* Le Gal (1959), which is similar to *P. bananicola*. In this species long thin spines develop irregularly over the spore surface but are aggregated particularly at the spore poles. Additionally, all three species, *P. bananicola*, *G. tapesioides*, and *G.*

luteorosella, have eguttulate ascospores that have refractive inclusions. Le Gal's somewhat abbreviated description of the excipular construction of *G. tapesioides* does not allow a complete comparision of its anatomy with that of *P. bananicola*. On the other hand, Le Gal did show the excipulum of *G. luteorosella* to be composed of a single more or less uniform layer rather than stratified as in *P. bananicola*. The excipulum in *G. luteorosella* is composed of a layer of elonglated cells. A collection from Gaudeloupe, F. W. I. (on mosses, rock and soil, Manceau above Capesterre along Riv. des Peres about 200 m, D. H. Pfister 598 FH) is identical to Le Gal's *G. luteorosella*. The excipulum is unstratified and the spores have the same distinctive type of ornamentation. I believe *G. luteorosella* should be accepted in the genus *Peziza*. The new combination is thus made: **Peziza luteorosella** (Le Gal) Pfister, **comb. nov.** ≡ *G. luteorosella* Le Gal, Bull. Jard. Bot. Etat. 29: 82. 1959. A deposition of *G. tapesioides* in *Peziza* would be logical but its identity will not be completely known until further studies are undertaken. Both of these taxa from Africa clearly require futher study from fresh or well-preserved collections. Rehm's name, *Plicaria bananicola*, is the oldest among those discussed above and can thus be used confidently at least for the Asian material.

I wish to thank V. Demoulin for providing the specimens for study. His work in New Guinea is supported by the Belgian FRFC, contract number 2.9001.90.

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Pfister, D. H. 1979. Type studies in the genus *Peziza*. V. Species described by Rehm. Mycotaxon 8: 187-192.

MYCOTAXON

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BOOK REVIEWS

L. M. Kohn, Book Review Editor

A Bibliography of Taxonomic Mycological Literature 1753-1821, by D. H. Pfister, J. R. Boise & M. A. Eifler. Mycologia Memoir No. 17, published for The New York Botanical Garden in collaboration with The Mycological Society of America. 161 pp., cloth hardcover, 143x233 mm, 1990. J. Cramer in der Gebrüder Borntraeger Verlagsbuchhandlung, Johannesstr. 3 A, D-7000 Stuttgart 1, F.R.G. (U.S. Agent: Lubrecht & Cramer, R.D. 1, Box 244, Forestburgh, NY 12777) ISBN 3-443-76007-4. DM 76.-- US$55.--

Efficient access to the mycological taxonomic literature for 1753-1821 has become critical following the revisions of Article 13.1(d) of the *International Code of Botanical Nomenclature* adopted at the Sydney and Berlin Botanical Congresses. This period brackets the newly designated designated starting point, Linnaeus' *Species plantarum*, ed. 1 (1753) and the former starting point, Fries' *Systema mycologicum*, Vol. 1 (1821). The compilations of R. H. Petersen, Pritzel, Lindau & Sidow, and Streinz have provided workers with an entry to the literature of this period, and indeed served as a preliminary entry for the authors of this volume. This new bibliography will be a central source for access to this literature in several respects. First, the new bibliography is comprehensive, including not only general references, but also a wide range of books and journal articles in which nomenclatorally significant names were published; the use of binomials or polynomials is indicated in entries. Second, each entry contains both descriptive information, such as citation of alternative printings and pagination, as well as several types of "locators" for acquisition of the cited material. These locators include references to other bibliographies, including Stafleu & Cowan's *Taxonomic Literature,* Second Edition, microfiche editions, libraries, and the *Union List of Serials in Libraries of the United States and Canada*. The Farlow Reference Library of Cryptogamic Botany at Harvard University is the central library resource (call numbers provided), although other Harvard Libraries, as well as those of the British Museum, Carnegie-Mellon University, Royal Botanical Gardens (Kew), Botanische Staatssammlung, and Missouri Botanical Garden are also cited. Coding is used for some types of data, but it is relatively simple and is fully described in the Introduction. Last among the resources offered in this volume is an appendix providing full names of periodicals cited, with information on availability in Harvard Libraries, microfiche editions, and cross references to the *Union List*. Tables provide publication information on Bulliard's *Herbier de la France*, *Flora Danica* , *Svensk Botanik*, *Deutschlands Flora*, Smith's *English Botany* , and Wulfen's *Plantae Rariores Carinthiacae*. This comprehensive compilation has been conscientiously designed for use by contemporary fungal taxonomists and will become an immediate standard reference through this, and subsequent editions. *L. M. Kohn, Erindale College, Univ. of Toronto, Canada.*

Fungi of Switzerland, Volume 3, Boletes and agarics 1st part, by J. Breitenbach and F. Kränzlin. 359 pp., laminated hard-cover, 216x288 mm, 1991. Edition Mycologia Lucerne, P. O. Box 165, CH-6000 Lucerne 9, Switzerland. English Edition, ISBN 3-85604-230-X; French Edition (Champignon de Suisse, Tome 3) ISBN 3-85604-130-3; German Edition (Pilze der Schweiz, Band 3) ISBN 3-85604-030-7. Sfr. 148.--

This third volume in the series, **Fungi of Switzerland**, under the aegis of the Mycological Society of Lucerne, is dedicated to Dr. R. A. Maas Geesteranus on the occasion of his 80th birthday. In this volume, 450 species are described, mainly from central Switzerland, with drawings of microscopic features and color photographs, following the format of the previous volumes (Ascomycetes, Vol. 1, and Heterobasidiomycetes, Aphllophorales, and Gasteromycetes, Vol. 2). This volume treats the Strobilomycetaceae, Boletaceae, Paxillaceae, Gomphidiaceae, Hygrophoraceae, Tricholomataceae, and lamellate Polyporaceae. Volume 4, in preparation for publication in 1995, will treat the Entolomataceae, Pluteaceae, Amanitaceae, Agaricaceae, Coprinaceae, Bolbitiaceae, Strophariaceae, and Crepitodaceae. Volume 5, still in the planning stages, will treat the Cortinariaceae and Russulaceae.

Like the previous volumes, this is an attractive book whose main strength is in providing high quality photographs (with descriptions of specimens) of a broad survey of species representing a wide range of genera, some of which are relatively obscure and rarely photographed. As H. Clémençon astutely suggests in the Preface, this first foray into the Agaricales takes the authors on a new, and challenging adventure. Floras and field guides on large fleshy fungi abound, replete with lavish, though not always useful, photography. In this crowded field, criticism can be severe, if not carping. The authors have taken this challenge very seriously. Methods of study are carefully explained; I was especially impressed by the care given to methods for spore rehydration and statistical applications for reporting spore dimensions. In this volume the normal distribution of spore measurements is the basis for the range reported in descriptions and the mean length/width ratios and volumes are also reported. Line drawings of macroscopic and microscopic features, a glossary and lists of abbreviations and plant names (Latin and common English names) are provided in the Introduction. As in the other volumes, keys to species in the text are provided. I (as well as my students) have found the keys in this series to be frustratingly artificial. The addition of keys to families and genera would have made organizational sense in this volume since species are arranged in the text by families and genera. Keys to families and genera would be more of a resource for those not working strictly with the Swiss/European mycobiota, as well as a less a purely functional (and artificial) access to the text.

The systematic basis is Moser's 1983 "Die Röhrlinge und Blätterpilze", although the current European taxonomic literature is widely treated. For example, species concepts in the Armillaria mellea complex are based on recent treatments (and are represented beautifully in the photographs). One of the great strengths of this volume is that it presents an excellent overview of the taxonomic status quo in a floristic context that will be uniquely valuable to professionals, students, and amateurs. The authors have used the strict guidelines of the Association of The Official Mushroom Control Officers of Switzerland (VAPKO) in reporting on edibility. I found the photographs to be of very high quality with excellent color, although they are limited in size due to the number of species included in a volume of fixed size and format. Especially when compared to Volume I on ascomycetes, the descriptions (and distributional data) are quite thorough for a floristic treatment. There are typographical errors; spellings of author's names (e.g., Müller and Mueller, Rose and Roze) can be slippery. This is, however a floristic treatment of the highest standards, one that will excite both experienced and novice mushroom hunters. Anyone interested in the European mushroom flora will want to own this, and forthcoming contributions in this series. *L. M. Kohn, Erindale College, Univ. of Toronto, Canada.*

Indentification Manual For Fungi From Utility Poles, I. The Eastern United States, by C. J. K. Wang and R. A. Zabel (eds.). 356 pp. + viii, paper, 280x215 mm, 1990. American Type Culture Collection, 12301 Parklawn Dr. Rockville, Maryland 20852. ISBN 0-93-0009-31-2.

This publication is the result of approximately 10 years of research on the fungi decaying utility poles in New York State. It arose from an earlier manual included as an appendix of a final report to the Empire State Electric Energy Research Corporation, but has obviously gone far beyond its humble beginning.

The manual is divided into four chapers: 1) a short introduction by the editors including an historical review of studies on utility pole decay, a characterization of decay types, a brief outline of fungal classification and an overview of the manual itself, 2) a brief discussion by R. A. Zabel and F. C. Terracina of sampling and isolation methods, 3) an examination by F. F. Lombard and G. P. Chamuris of methods for isolating basidiomycetes from utility poles followed by detailed descriptions and illustrations of 32 species in culture, distinguished by a tabular synoptic key, and 4) a treatment of microfungi by C. J. K. Wang similar in format to chaper 3 but including a dichotomous key. Each chapter includes its own bibliography. There are two appendices: Appendix A outlines test procedures used for decay and soft-rot determinations, while Appendix B covers procedures used for anatomical study of decaying wood.

The two chapters dealing with basidiomycetes and microfungi take up about 330 of the 360 pages of the text and are the reason most people would want the book. Both of these chapters are conventional in approach and place everything where users will expect them.

The basidiomycete chapter provides an outline of the Davidson and Nobles systems for coding cultures and includes both codes with each description. Growth and hyphal characteristics as well as distinguishing features are provided in separate paragraphs. Photographs of colonies of one or more (usually two) strains of each species are on a separate, usually facing page along with line drawings of taxonomically useful structures.

The chapter on microfungi includes a few zygomycetes, ascomycetes and coelomycetes as well as numerous hyphomycetes. One basidiomycete, *Pachnocybe ferruginea* (Sow.:Fr.) Berk., is included because its basidiomata and basidia are likely to be mistaken for synnemata and conidiophores. The keys to genera of microfungi are not strictly dichotomous but are indented and easy to use. The genera of hyphomycetes are separated according to a modified Hughes system and appear to be quite workable. Accompanying each group of keys are clear photographs of the genera involved. The species descriptions include both cultural and microscopic characteristics and are accompanied by a paragraph of relevant remarks. Illustrations are on a page facing each description and are composed of a photograph of a typical colony and several photomicrographs of taxonomically important structures.

A book such as this might appear to be of rather limited appeal: useful only on those occasions when one is sent a decaying utility pole. However, it describes and illustrates 113 taxa occurring in an ecologically circumscribed niche and is undoubtedly useful beyond the realm it was designed to cover. In addition it contains a wealth of information on methods for cultivating and examining wood-decaying fungi. Its widest application may be in the classroom, where relatively inexpensive identification manuals are always in demand. For the student or non-mycologist this book will be an excellent and unintimidating introduction to practical mycology. The professional mycologist may find little that is new here other than a list of fungi that decay utility poles. Virtually all of the taxa have been described and illustrated before. On the other hand, I suspect that it might be the first place to look when identifying an unknown isolate from decaying conifer wood regardless of its source. Overall, I think that few purchasers will be disappointed. *D. W. Malloch, Dept. of Botany, Univ. of Toronto, Canada.*

MYCOTAXON

Volume XLI, no. 2, pp. 513 July-September 1991

NOTICE

FOND FAREWELLS AND HEARTFELT WELCOMES

Volume 40 of MYCOTAXON concluded over seventeen years of service as Managing Editor and English Language Editor for Dick Korf, and nearly as many years of service, at first uncredited, and later acknowledged as Assistant Editor, Associate Editor, and Index Editor, by Susan Gruff. Korf will continue with the journal, in charge of the Order & Subscription Department.

We leave the journal's production to the editorial skills of Dr. Jean R. Boise, in the new post of MYCOTAXON *Editor-in-Chief*. She has selected admirable helpers as Associate Editors: Dr. Grégoire L. Hennebert (continuing his service as one of the founding co-editors) is French Language Editor, Dr. Linda M. Kohn is Book Review Editor, and Mr. Robert Dirig is Index Editor. We welcome them and wish them all the best of luck.

The retiring Managing Editor, Dick Korf, wishes to apologize for the delay in publication of volume 40, the January–March 1991 issue, which was caused by his hospitalization from January 6th through April 6th. He owes a great debt to Susan Gruff, who saw volume 40 through to its final mailing in May. The good wishes conveyed by those subscribers who knew of his illness are gratefully acknowledged here.

We are now at work on producing the 20–volume Index for Volumes 21–40, which should appear later this year.

Not long ago an Editorial Advisory Board for MYCOTAXON was appointed, consisting of six eminent mycologists who have agreed to assist the new Editor-in-Chief and to insure the continued excellence of the journal. We hope our subscribers will also welcome that Board and all four Editors, and that MYCOTAXON will continue to flourish with the infusion of their new ideas.

RICHARD P. KORF
SUSAN C. GRUFF

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REVIEWERS, VOLUME FORTY-ONE

The Editors express their appreciation to the following individuals who have, prior to acceptance for publication, reviewed one or more of the papers appearing in this volume:

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INDEX TO FUNGOUS AND LICHEN TAXA, VOLUME FORTY-ONE

This index contains the names of genera, infrageneric taxa, species, and infraspecific taxa. New names are in **boldface**, as are the page numbers on which new taxa are proposed.

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Page 383	line 45	*for* Cetrareia	*read* Cetraria
434	5	for nicaragense	read nicaraguense

ERRATA, VOLUME FORTY

Page 48	line 8	for *kumaonicus*	read *kumaonica*
87	6	*for* 264	*read* 2621
116	1	*for* A. H. Chivers, J. H. Miller, *read* J. H. Miller, A. H. Chivers,	
202	33	for *cuculata*	read *cucullata*
315	31	*for* 2567,	*read* 2567 (UPS)
433	13	*for* Isotypes	*read* Isoparatypes
463	36	for *Acanthophyscium*	read *Acanthophysium*

ERRATA, VOLUME FORTY-ONE

The new Editor-in-Chief apologizes for some problems with pagination of the volume. The omission of page numbers 234 and 235 resulted in misnumbering of the article. Page 224a, following 224, and 261a, following 261, were added in proof. So, volume 41(1) does contain exactly 320 pages as indicated on the cover.

Page 460	for *Tubeufia cera*	read *Tubeufia cerea*
464	for *Cacumisporum*	read *Cacumisporium*

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